Constructive Convergence:

Imagery and Humanitarian Assistance

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Doug Hanchard is the President of Rapid Response Consulting (Toronto, Ontario), an ICT consulting firm specializing in telecommunication services for enterprise organizations and government agencies. Hanchard has worked at Bell Canada, TELUS and AT&T implementing and delivering telecommunication solutions worldwide in 57 countries.

In memory of Ivan W. Hanchard

Collaborator, negotiator, and, most of all, a father
who taught wisdom based on experience.

Contents

Foreword

In the past few years—especially since the 2010 Haitian earthquake—Geospatial Information System (GIS) products, often based on imagery, have become critical enablers of humanitarian assistance and disaster relief (HA/DR) efforts. Much more imagery is becoming available to the HA/DR community, complemented by increasing bandwidth to share it, more powerful "edge" devices to process it, global volunteer groups to help make sense of "crowd-sourced" information and high-level policy and doctrine that are becoming more supportive of collaboration around GIS products in HA/DR environments.

Doug Hanchard's paper makes an important contribution to this field. He does not try to be all things to all people, but focuses on important technological aspects of imagery in HA/DR. The paper includes specific recommendations, from transmission standards, to short message service shortcodes, to application programming interfaces and data search techniques. At the same time, he recognizes that technology alone is not enough:

- Social networks need to be developed and trust built to encourage diverse groups to work together
- Policy and doctrine need to be translated into effective field operating procedures so that people "on the ground" know what to do
- Legal and regulatory constraints must be understood and challenged where necessary
- Resources must be addressed and acquired
- Trainers must be trained, units exercised and curricula adapted to achieve genuine lessons *learned*, instead of lessons *observed*, and re-observed, and re-observed.

Importantly, the paper ties imagery to logistics and to local populations in their worlds, with their resources. This reinforces a model, developed from Haitian and Afghan experiences, which suggests that organizations need to build "bridges" to the "crowd" that is generating so much information.[1] Handling the volume and velocity of information created by social media and the 24/7 news cycle will be essential for all organizations going forward. At the same time, unless "transactions" are completed that make a difference on the ground (people pulled from rubble, supplies delivered, contracts fulfilled) improved situational awareness doesn't help much—hence the importance of logistics. Finally, "feedback" is needed, both to make the transactions more effective and to inform the "crowd" (the international community) about what's happening.

Doug repeatedly points out that "people save lives, not technology," and his solutions emphasize ways that technology can help make people more effective, not be an end in itself. The complicated environments of most HA/DR scenarios require that practitioners seek to achieve "unity of action" when there's no "unity of command," and his recommendations provide tangible steps to help achieve this most difficult goal.

—Linton Wells II
Director, Center for Technology and
National Security Policy,
National Defense University

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[1] L. Wells and R. Welborn, "From Haiti to Helmand: Using Open Source Information to Enhance Situational Awareness and Operational Effectiveness," (Center for Technology and National Security Policy, December 2010), available at<http://star-tides.net/sites/default/files/From%20Haiti%20to%20Helmand%2012%2011%2010%20v14_0.doc >.

Executive Summary

Imagery assessment is a vital tool for humanitarian responders when disaster strikes. Whether derived from satellite, aircraft, unmanned aerial vehicle (UAV) or ground views, imagery offers event confirmation and impact, an early assessment and a foundation on which to initiate response planning. The goal of this paper is to illustrate to the technical community and interested humanitarian users the breadth of tools and techniques now available for imagery collection, analysis and distribution, and to provide brief recommendations with suggestions for next steps.

Over the past decade, the humanitarian community has found its growing access to imagery to be valuable and organizational policies are changing to reflect that importance. Humanitarian response organizations have also paved new paths forward when the existing methods were antiquated (some of which are described below). As new methods are adopted, changes in the use of imagery may alter organizational command structures.

Innovative technology, like imagery and the information derived from it, has long been a hallmark of human evolution—but using it wisely has been a challenge. There are legal, political and ethical questions that quickly arise around the use of imagery in disasters. In addition to the legal and ethical issues, humanitarian assistance requires teamwork and collaboration. Responders using imagery must overcome interoperability challenges, develop technical standards, create governance structures and protect both personal privacy and intellectual property. In some cases, those posting or using imagery in the field may be at physical risk. Recognizing those needs, a growing number of volunteer technical groups have an opportunity to design tools that reflect current technical capabilities while addressing the full spectrum of requirements. We can now include imagery contributions from affected populations to a degree never before possible, which raises further opportunities for the design of new tools and processes.

Today's technologies include public access to satellite and aerial imagery platforms; resilient networks; and larger and faster data storage capabilities at data centers, on smart phones and tablet computers that are capable of manipulating imagery files using surprisingly high-performance applications that reside locally on the device. Such a convergence of capabilities is uncommon. This paper is intended to stimulate discussion on that convergence around the use of imagery in humanitarian response, and to inform readers about the resources available for research in more depth.

I. Introduction

"Imagery is like fish—best when it's fresh."
—Major General John Hawley (USAF Ret.), U.S. Space Command

Disaster Strikes

An earthquake occurs in a city of 375,000 people. As reports are digested the scale of the disaster becomes clear, revealing an estimated $30 billion in damages and resources are overwhelmed. Compromised energy resources limit communications for situational awareness, and there isn't enough manpower on the ground. Volunteers from humanitarian groups, especially if they can help manage information, would be useful, but civil defense officials don't have any experience integrating volunteers to a government response plan. Could volunteers be deployed?

On February 22, 2011, Christchurch, New Zealand, did just that—urgently defining, over a matter of hours, a new process for integrating a volunteer technical community into an emergency response. Professional responders in New Zealand used volunteers, private communications networks, Internet-based tools provided by private companies and nongovernmental organizations (NGOs) to create a mesh that fed the emergency management community the data needed to improve its response. That devastating 6.3 earthquake became a laboratory to carry out a complex, yet necessary, coordination of these technical efforts across the professional and volunteer boundary. The results demonstrate how open-source maps, layered satellite and aerial imagery, and open-source information tools can be rapidly integrated into donated logistics software to empower volunteer teams using any available mobile device. In close collaboration with the municipal government, a voluntary technical community delivered desperately needed information services with very little warning and with a flexible, adaptable model that may be worth replicating.

The success of the volunteer coordination in Christchurch was largely due to the converging uses for imagery among the humanitarian assistance and disaster relief (HA/DR) community. Imagery can be derived from sensors on satellites, planes or even from cell phone and digital cameras, and provides a picture of a place on earth at a point in time. The ability to acquire and share these images with coordinated response groups has been revolutionized by recent efforts that led to several successful rescues and rapid community healing in Christchurch. Christchurch is unique: two severe earthquakes occurred separately. The events happened quickly, without warning.

This paper presents a brief overview of the growing power of imagery, especially from volunteers and victims in disasters, and its place in emergency response. It also highlights an increasing technical convergence between professional and volunteer responders—and its limits.

The Power of Imagery

Imagery for HA/DR is used for three primary purposes: situational awareness assessments by the scientific community, government and the community; response logistics for search and rescue, medical assistance and essential service assessments; and recovery management for clean-up, interim essential service distribution and post-disaster reconstruction efforts.

The immediate aftermath of a disaster is chaotic, and post-event imagery can provide relatively unbiased logistical information for rescue operations. Traditionally, there have been significant limitations to gaining access to imagery for people responding to an event since civil and military governmental agencies used to be the sole owners of satellite imagery. But now high-resolution imagery (in both space and time) is commercially available, providing nearly real-time situational awareness. Further, with the creation of such organizations as OpenStreetMap (OSM) and Ushahidi, we are beginning to integrate cartography into what can be best described as social mapping, breaking the bi-directional barriers to accessibility. However, the case studies below have shown that access to this imagery has created challenges in management and distribution.

Imagery for far-forward situational awareness began to become broadly available during hurricanes Katrina and Rita in the Gulf of Mexico in 2005 (Figure 1). NGOs, international organizations (IOs), and volunteer groups began to leverage this new access to convey information to the general public. Since then its use has accelerated. After the 2010 Haitian earthquake, the use of imagery by non-government groups changed how HA/DR communities approached many typical disaster response issues. During those 5 years, imagery access began to affect how government emergency operations, policies, procedures, search and rescue planning, and logistics services were developed and how humanitarian assistance teams trained and deployed.

Technological advances in other domains have co-evolved with the access to imagery. Film-based camera systems have been replaced with next generation charge-coupled device (CCD) chips integrated with next generation photographic lenses in aerial and satellite platforms. These advances have increased the resolution and thus the size of the image files and the demand for space to archive it. The data centers now required to manage these file sizes must be accessible in the region where the disaster occurs and in reach back areas not impacted by the event. That requires broadband connectivity. At the same time, first responders must be ready to use low bandwidth methods, such as text-messaging if bandwidth is limited.

Open source mapping tool add-ons, such as KML, PATH, GRAPH, KML Color Converter[2] for Google Earth, use imagery as a foundation for layering field data. But with this availability the amount of information that can be collected is skyrocketing, which means the risk of information overload is also rising. Techniques to manage and use these tools must be carefully assessed and coordinated. Network providers are experiencing daily impacts to voice and data networks by the demands for data sharing, which are made worse in a disaster zone.

Advancements in handheld devices now enable network connectivity in the disaster-affected area. These rugged devices are now capable of transmitting and consuming vast amounts of information. In addition, satellite and emergency terrestrial wireless networks are able to deploy within hours. While most communications systems today generate decent connectivity on the ground in normal circumstances, care must be taken as to how organizations and volunteer groups compile and publish information over limited and fragile data pathways in a disaster. That requires a degree of understanding and cooperation not yet common in an urgent response.

To coordinate efforts in a disaster environment, a few social networking tools are being integrated by HA/DR groups. Those tools offer knowledge sharing opportunities that did not exist 10 years ago but contribute to information overload. This allows critical pieces of information to be easily overlooked, and there is additional danger in automating the data filtering.

To collect, optimize, and deploy satellite and aerial imagery successfully, we must consider these issues carefully. Each section in this paper will guide the reader through current and future challenges, opportunities

[2] Open source (freeware) tools: http://www.sgrillo.net/googleearth/

and ideas with recommendations for consideration. Imagery does not often lie and only rarely is it misconstrued. Each image or map in the appendix tells a story. What is driving the story is the converging use of imagery on the ground.

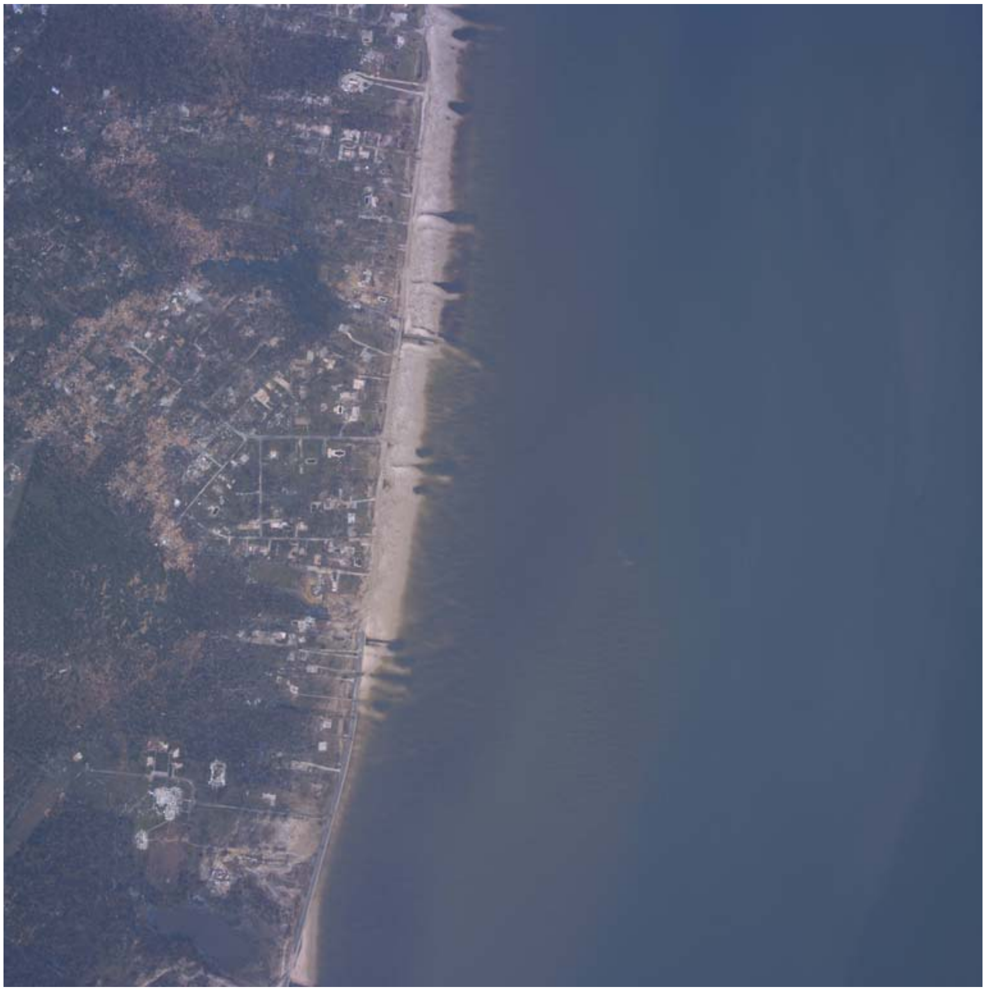

Figure 1. Hurricane Katrina NOAA Image. Original Size: 1,114 Kilobits − 4077 x 4092 Pixels

270359.85 m E − 3350705.72 m N − August 30, 2005 15:58:54 CDT[3]

This image was taken and published by NOAA on its Internet website. However, its value to first responders was minimal because information that could have helped analyze the image was not embedded was not, and no geospatial standard was used to allow the image to be exported to other mapping services and technologies.

II. The Users of Imagery

HA/DR Community: Learning New Visualization Concepts

When a disaster strikes, the organizations that deploy to respond have different objectives. Thus their needs, policies and procedures are different when addressing the "who, what, when, where and why" of the event. What they want out of an image is different and it is unlikely that any one solution to imagery will ever be found to address everyone's needs. Moving forward, care must be taken so as not to put useful cooperation

[3] http://ngs.woc.noaa.gov/storms/katrina/24334501.jpg

at risk when imagery-related needs are at odds. The existing inter-agency and government compliance requirements that, in some cases, are in conflict with demands for information generated by the event, which further complicates matters.

Government (Civil)

Some government structures are based on local culture and historical precedents. Some are based on religious beliefs and some are tribal or ethnic in nature. Some are autocratic, devoid of oversight or cooperation. In some regions of the world, abstract technical sophistication is limited and interpreting a basic map is beyond local capabilities. But in virtually every country, there is a sense that civil government should provide useful services to people. Imagery of various kinds is emerging as a potentially valuable service.

Governance structures at many levels are beginning to recognize the value of post-crisis and near real-time imagery as well as pre-crisis planning. Static web pages no longer meet the needs of constituents nor of emergency operation centers. New dynamic sources of information such as social media and open source imagery can inform but also overwhelm planning and response mechanisms. The challenge for governments is often to address the legal limitations that hinder new approaches to information sharing with volunteer organizations. Economic conditions often further limit government financial support for internal training and workshops even when sharing is allowed and volunteers welcomed.

Government (Military)

The armed forces are often the most valuable resource on which any government can to lean during and immediately after a catastrophe. Every executive government branch will be tasked for communications, transport, and power. But the military may also be able to provide: Field medical services, emergency construction capabilities, additional essential supplies, engineering, field coordination, logistics operations and management and aerial surveys. Host-nation militaries often own, or have access to, the highest resolution post-event imagery in the country. In some countries they may provide the only emergency services available. Humanitarian operations frequently are integrated as multi-national, civil-military deployments as was the case in Indonesia and Haiti. Militaries, therefore, are exploring new approaches to HA/DR as demands escalate. The U. S. Department of Defense (DOD) clearly recognizes the requirement for collaboration and how it must function in humanitarian assistance and disaster relief. This is reflected in a series of DOD directives and instructions. One of most forward leaning is DOD Instruction 8220.02, *Information and Communication Technology (ICT) Capabilities for Supporting Stabilization and Reconstruction, Disaster and Humanitarian Assistance and Civic Operations.*[4] Similar themes are found in: *DOD Directive 3000.05, Military Support for Stability, Security, Transition, and Reconstruction (SSTR) Operations, November 28, 2005,*[5] reissued on September 16, 2009 as a DoD instruction on Stability Operations.[6]

NGOs/IOs

When a major disaster strikes the developing world, there are more than 40,000 different NGOs and IOs that may consider responding. They deploy to address specific needs and goals defined by the organization, and usually must leverage existing resources to do so. Collaboration with other NGOs is often indispensible.

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4 http://www.dtic.mil/whs/directives/corres/pdf/822002p.pdf
5 http://www.usaid.gov/policy/cdie/sss06/sss_1_080106_dod.pdf
6 http://www.dtic.mil/whs/directives/corres/pdf/300005p.pdf

Volunteer and Local Community

The public no longer relies on conventional news organizations as their primary source of information. The ability to go directly to the source of information online, post comments and offer assistance is growing with every new disaster through the capabilities of mobile phones, short message service (SMS), multimedia messaging service (MMS), Flickr, Facebook, Twitter, Kiva, tools from the NGO "Innovative Support to Emergencies, Disease and Disasters" (InSTEDD), Ushahidi, OSM, and others. This publically generated data presents challenges to managing unverified information. Contributions from a diaspora of globally distributed people familiar with the impacted area have also proven valuable, but their use needs refining.

Working Together: Simulation and Coordination Groups

Some groups have recognized the need to collaborate and be formally organized in order to prepare for anticipated events. Here are some (of many):

Net Hope

Net Hope—a consortium of 32 of the largest global NGOs—was established in 2001 to research innovative approaches to cooperation, knowledge sharing,[7] defining technology and services required to accomplish their goals.[8] Many of the most recognized NGO information technology (IT) departments have joined this consortium.[9] For Net Hope, accurate geospatial information applications are a critical need. One of the group's goals is to develop standards for solutions that can be replicated to reduce capital costs, increase efficiencies and simultaneously expand their capabilities. They are generating internal standards and protocols for imagery, data flow guidelines, network communications, device usage, and ancillary systems.

Exercise "Pacific Endeavor"

Field trials and planning for multi-national humanitarian civil-military response teams are occurring with multi-national integrated military exercises such as *Pacific Endeavor*.[10] The program commonly involves 16 different countries around the Pacific Rim and focuses on establishing communication network interoperability across voice and data network services. In the recent past, the military was the sole owner and supplier of post-event imagery. Now imagery is produced by many organizations and the military role is being reversed from producer to consumer of not only imagery, but maps and new interfaces in which data is layered on top of the imagery.

Exercise 24 (X24)

Military organizations—like their civilian brethren—are feeling financial restraints on research and development budgets while exploring next generation tools. San Diego State University developed an innovative approach to reduce the costs associated with running field exercises. Their solution was to simulate a disaster and run the exercise as a virtual event online. The program was tested in September 2010 using a scenario in Southern California involving a large earthquake that generated a tsunami. In March 2011, the exercise was repeated, this time with a scenario in Europe and the support of the Red Cross of Germany, National Institute for

[7] http://www.nethope.org/about/us/
[8] http://www.nethope.org/
[9] Members of Net Hope: ActionAid, Ashoka, CARE, CHF, Christian Aid, ChildFund International, Children International, Catholic Relief Services, Concern Worldwide, FINCA, Family Health International, Heifer International, International Rescue Committee, International Federation of Red Cross and Red Crescent Societies, Mercy Corps, Nature Conservancy, Opportunity International, Oxfam, PACT, PATH, Plan, Relief International, Save the Children, VSO, WaterAid, Wildlife Conservation Society, Winrock International, and World Vision
[10] http://www.dvidshub.net/news/55232/pacific-region-militaries-join-humanitarian-community-pacific-endeavor

Urban Search and Rescue, CrisisCommons, and the U.S. European Command. More than 12,500 volunteers and organizations participated from 79 countries in the first X24, and more than 18,000 from 92 countries in the second.[11] A key component of this new approach to training through an online simulator was the use of cartographic applications that layered data published by volunteers. The military participants witnessed the avalanche of available information. It was reportedly an eye-opener for many and it appeared to be educational for participants at all levels.

This exercise formed a Virtual Civil-Military Humanitarian Operations Center. Their design was not new, but using data and software applications from civilian and volunteer organizations capable of infusing data in a rapid and accurate mapped fashion *was* new and had an impact. The next challenge will be integration; seeing how well these organizations can adapt to non-military designed services and applications, many of which today fall outside of military network security regulations and policies.

Imagery Sharing Organizations

Various volunteer and commercial reach back groups are both consumers and distributors of information. This is a significant issue as there are many different platforms that are being used to compile a map product. These organizations—like Ushahidi, All Partners Access Network (APAN), CrisisCommons and OSM—can serve as resources for disaster information, and they use imagery as a base on which to layer their datasets. If, however, the map product is created from a proprietary or classified software package, these data layers are not easily distributable on other platforms, even if completely unclassified and non-proprietary (see figures 7 and 8.) Some organizations have recognized this obstacle and do not use imagery at all because of the legal and regulatory restrictions on devices mandated by their organization. If imagery is to be shared among different organizations, then international standards that meet corporate and governmental requirements are necessary.

III. Imagery: Types and Uses

Imagery of disasters can provide critical information for search and rescue, medical services, shelter, and can support ancillary resources such as logistics planning. The source of the image and technology that produces them determines the spatial resolution of the resulting image. Resolutions are now available from commercial and military satellites down to 10 centimeters per pixel and finer.

Satellite Imagery

Satellite-based systems take images of the earth and transmit them to the ground upon acquisition. They can offer high spatial resolution and broad spectral resolution depending on the sensors on the satellite. The advantage of satellite imagery over aerial-based systems is that the orbit of the satellite is already known, and can register the bounding coordinates of the image to it automatically. This allows users to project the image to a 2D map, which enables geospatial data points to be plotted with it. The dominant handicap of satellite-based systems is that weather conditions can impact visibility of the ground. Vendors of advanced digital imagery available today comply with standards developed by organizations including the American Society for Photogrammetry and Remote Sensing[12] and the International Society of Photogrammetry and Remote

[11] http://x24.eushare.org/ - The author observed and participated in this event.
[12] http://www.asprs.org

Sensing.[13] However, these standards do not imply interoperability or transferability from one software or hardware platform to another.

Aerial Imagery

Aerial imagery is acquired by a camera attached to a plane or an Unmanned Aerial Vehicle (UAV). Because it is not in a fixed orbit, aerial platforms can fly multiple missions over a disaster area, thus providing much more flexibility in temporal and spatial resolution. Aerial images are often supplemented with verbal and written situation reports, providing further metadata on the image. Advantages over satellite imagery include the ability to fly below cloud cover, and improving the spatial resolution by altitude variation. Maximum aerial imagery resolution is now available at 10 cm or less using advanced digital imaging platforms. The most common and difficult challenge is to geo-rectify images to the same accuracy as a satellite in near real-time. Commercial aircraft platforms are subject to wind-drift and unintended altitude variations, even with sophisticated autopilot and GPS managed flight navigation systems. Next generation systems now appear to address these issues effectively (see figures 43 and 44.) Advanced government aerial image systems eliminated most of these problems in the 1990s and are capable of registering imagery and embedding it into visualization platforms rapidly, but those tools are not commonly available on non-military platforms. Commercial map providers are beginning the move toward application program interface (API) tools to alleviate problems experienced in the field. Response times are improving, facilitating quicker publishing and manipulation of the images.

Images from Social Media and Hand-held Devices

Modern humanitarian assistance groups draw on information sources that are no longer confined to official government sources. Today, individuals and local communities publish information during and after a crisis event using Internet-based social media websites such as Facebook, YouTube, Wikipedia, Flickr and Twitter. Pages and articles can now be extracted by HA/DR responders and exported as metadata to other software applications. The social media sites have been both a source and destination for metadata during disasters.

The use of social media applications has not gone unnoticed. The United Nations developed several courses on social media under its United Nations Institute of Training and Research that directly address Facebook, Flickr, YouTube, Twitter and others.[14] With these tools responders can detect, monitor, report and record knowledge points within seconds of an event. These flows of information are compiled as datasets. The data is often open source and therefore exportable to multiple applications and platforms such as Sahana and Ushahidi.

IV. Computing to Enable the Use of Imagery

It is clear to HA/DR map experts that imagery has significant value when correlated with other sources of information. But to do this in the field, responders need software to read, analyze and share the imagery. Below is a snapshot of some software tools that enable each.

[13] http://www.isprs.org/technical_commissions/
[14] http://www.unitar.org/ksi/innovative-collaboration-development

Software Applications

Geographic Information Systems

A geographic information system (GIS), sometimes referred to a *geospatial* information system, is a system designed to work with data referenced to spatial or geographic coordinates.[15] An early example was an epidemiological map of a cholera epidemic in London made by John Snow and colleagues in 1854.[16] The map showed the location of the outbreaks in relation to the water pumps and led to an effective intervention. A digital adaptation to mapping was developed by the Department of Forestry of Canada[17] in 1960. The Canadian Geospatial Information System became the foundation for today's computer GIS standards. It remained primarily a government set of tools for decades, and did not become widespread in commercial applications until the 1980s. With these standards in place and the use of computer-based maps now possible, new opportunities in cartography offered the ability to layer information for commercial and consumer applications. No longer confined to 2D maps, computers offered accuracy since data could be shown in 3D. It would take almost 35 years to become known outside of professional communities, but the growth of GIS since 2005 has been explosive.

Global Positioning System and a Reference Standard

Small-form factor Global Positioning System (GPS) map devices used in Marine and Aviation industries started the digital field-mapping revolution. In the mid-1980s, these devices were built into consumer devices such as small aircraft and pleasure boats as navigation tools, which spread quickly to automobile navigation systems. In 2001, a small company named Keyhole developed an Internet-based cartographic application on a globe. Google acquired Keyhole in 2004, modifying it and renaming the Keyhole tool "Google Earth." Google soon began working with authoritative bodies on projection and representation standards. Now Google Maps, OSM, Bing, and others use the World Geodetic System (WGS) 84 projection described further in this book,[18] which has become the Web mapping projection standard around the world.

Metadata

Metadata is data about data, and is either embedded in the geographic data file or is made available as an independent file that the geographic data reads. It defines the object's grid coordinates (such as latitude, longitude, and resolution) and it's used to map geographic data accurately on a map. It also enables additional geo-referenced data to be layered over it. In the 1990s, metadata standards for commercial photogrammetry vendors were available for both digital and film formats, and they are still in use today. Metadata can also include attribution information, such as a description, of the geographic area being plotted. Examples of metadata for HA/DR response include when an image was taken, by whom it was taken and how many staff work in the medical clinic seen in the image.

The Global Disaster Alert and Coordination System (GDACS),[19] operated by the United Nations Office of Coordination of Humanitarian Affairs (UN-OCHA), uses GIS metadata to generate alerts that are then plotted onto a GDACS-provided map, and, in parallel, are then sent as information alerts by really simple syndication (RSS)[20] or email.[21] This is done through use of a mapping standard defining externally-sourced information

[15] Star and Estes by Jeffrey Star and John Estes, 1990
[16] http://en.wikipedia.org/wiki/The_Ghost_Map
[17] http://www.cdci.ca/HGIS_Mapping_v2.pdf
[18] http://wiki.openstreetmap.org/wiki/EPSG:3857
[19] http://www.gdacs.org/
[20] http://www.rssboard.org/rss-specification

streams, plotting data onto a map, and then publishing a finished map either on the Internet, on paper, or stored in a computer as an archive. With those tasks accomplished, many subscribers of these maps then layer their own metadata onto these "foundation" maps through Application Programming Interfaces (APIs), Java, or similar scripting languages that allow them to create their own maps and information elements (see below for a description of APIs.)

Web Browser Applications

Many Web applications that were originally intended for social networking are now being used for disaster response assessments. Advances have been made in Web application services that enable interoperability between them. Examples include the ability to map satellite imagery and embed third-party datasets from applications such as Twitter and Flickr. The third party datasets can be collected from a variety of sources including smartphones, social network services and volunteer input data sets. Web portals informing HA/DR teams of current conditions in real time are being published on sites using Ushahidi, Riff, Crisis Mappers Net and SwiftRiver.[22] An additional benefit to these sites being online is that they also provide information to the general public. These websites are integrating data streams from Twitter, SMS,[23] and volunteer databases in addition to satellite imagery and open source maps. Some Internet applications have designed specialized versions of their services for mobile phones like Bing Maps, Google Maps and others are now widely available.

Web Map Service, Web Mapping Tile Service (WMS/WMTS)

To share high-volume imagery on maps, the imagery can be published on the Web through a Web map service (WMS),[24] a standard protocol for serving geo-referenced map images over the Internet. A WMS generates images through a map server using data from a GIS database. WMS software reads the embedded metadata for an image—location, resolution, number of pixels—and places the image on a 2D map. Image sets are formatted as "tiles" or a series of strips that can be stitched together for easier data navigation. Some vendors, such as Google, use a WMS (such as Google Maps and Google Earth) that processes the imagery into a proprietary format that allows the user to view the processed imagery easily, but cannot extract the image for use in another mapping software. In other cases, a WMS allows the user to download raw images and use them with other applications. In order for image sharing to occur, other mapping standards are required (such as using a common map projection). Some service bureaus use another Web mapping protocol called Web mapping tile service (WMTS), which carries the same function as WMS, but is technically a different software application.[25] WMTS uses extensible markup language (XML) (see below) to interface with the imagery metadata to tile the images onto a digital map.

Application Programming Interface (API)

The ability to add additional geographic datasets from disparate sources with imagery is accomplished by using API tools. An API takes data from its source and processes it into a dataset that can be read by the software interface of your choice. They have become the backbone for integrating third party information sources onto maps. Examples of common APIs are Java, Sensor Model Language (SensorML), JavaScript

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[21] http://www.gdacs.org
[22] http://swift.ushahidi.com/
[23] http://www.shortcodes.com/howto_short-codes.html
[24] http://www.opengeospatial.org/standards/wms
[25] http://www.opengeospatial.org/standards/wmts

Object Notation (JSON), XML, Geography Markup Language (GML) and Keyhole Markup Language (KML), all described below.

Google has created an API for users to manipulate its maps.[26] This allows developers of databases (regardless of their format) to build datasets that work with Google Earth. Microsoft has a wealth of resources available to developers on the Microsoft Bing Map site and Bing Map Blog.[27] The company also offers a software development kit (SDK), which allows Bing Maps to work on Android devices (including RSS) using its AJAX Control version 7.0 package.[28]

The First API: Sensor Model Language (SensorML)

In 1998, the U.S. Government created the Committee on Earth Observing Satellites, endorsed by agencies including the Environmental Protection Agency (EPA), NASA, the Defense Information Systems Agency, and satellite manufacturers including General Dynamics and Northrop Grumman. This committee, in cooperation with the Open Geospatial Consortium (OGC), developed SensorML.[29] SensorML offered the first standard in which metadata associated with a digital cartographic image could be correlated and given a description. Since the development of SensorML, other API standards have been developed such as XML[30] protocol (see explanation for XML below), which is related to SensorML. Another API is GML, which offers similar features and protocol concepts. In 2005, OGC released version 3.1.1 of SensorML in which GML is encapsulated. This allows protocols like GML, GEO[31] (eXtensible Hypertext Markup Language [X-HTML]),[32] JSON, XML and KML to add additional geographic data as new layers onto a virtual map.

JavaScript Object Notation (JSON/GeoJSON)

JavaScript Object Notation (JSON) is a software programming language that is a lightweight form of the JavaScript programming language. It can quickly parse data, including imagery, and import it into a text format that is language-independent (in the programming sense) but uses conventions that are familiar to programmers from C, C++, C#, Java, JavaScript, Perl, Python and others.[33] Its primary advantage is that it uses less code than XML. GeoJSON is the correlative mapping programming language used to plot data on a map. It is used widely by the open source mapping community and supported by many GIS software packages.

Extensible Markup Language (XML)

XML is a protocol used to interchange data between different encoding formats. XML use is widespread and popular for sharing documents between competing applications (e.g., Microsoft Office to Apple iWork). Software image processing applications can publish metadata into XML so it can be used immediately with WMS-formatted maps and with specialized survey maps and applications. Other XML applications using external metadata layers into crisis maps include Twitter[34], RSS[35] and YouTube.[36]

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[26] http://code.google.com/apis/maps/documentation/javascript/
[27] http://www.bing.com/community/site_blogs/b/maps/default.aspx
http://www.microsoft.com/maps/
[28] http://www.bing.com/community/site_blogs/b/maps/archive/2011/03/31/bing-maps-android-sdk-available-on-codeplex.aspx
[29] http://www.opengeospatial.org/standards/sensorml
[30] http://www.w3.org/TR/REC-xml/
[31] http://microformats.org/wiki/geo
[32] http://en.wikipedia.org/wiki/XHTML
[33] http://wiki.geojson.org/What_is_JSON%3F
[34] https://dev.twitter.com/docs/using-search

Geographic Markup Language (GML)

GML is an XML-based API to link GIS data and a Coordinate Reference System (CRS). GML is often used as the reference schema for geospatial objects. Google's KML for example can extract data from a GML file but not the other way around because Google's KML uses a different CRS and may not interoperate with KML-embedded metadata. GML is continually updated by community users.[37]

Keyhole Markup Language (KML)

KML is also an XML-based interface that uses Java-based programming to bind data from a remote source into a new data layer. Three different versions of KML are widely used because of the ease in which it can be used in Google Maps and Google Earth. Google's Earth and Map application resources can be found on its Lat Long Blog.[38]

Application Standards: An Impediment in the Making

Data is no longer confined to static sources. The Internet social revolution offers data from a variety of sites including Twitter, Facebook, RSS feeds, SMS and MMS, and many others. The structure of this data is often extracted as simple Comma Delimited Value or Delimited Set Value format. This has created an explosion of possible sources of information that can be mapped. Developers have taken advantage of social media linking tools and exported them to mapping solutions.

Applications used for mapping start with the simplicity of plotting reference data. But there are now more than 25 different database variants, 75 database tools to import and export datasets, and 60 query tools available for mapping. Some tools are specialized to only run on specific machines such as Microsoft, Apple, Linux or Unix operating systems.[39] Some databases are only accessible using proprietary software clients, while the ones that are based on Web browsers use different scripting languages such as ActiveX or Java.

Almost any programming language can be used for mapping applications and the decision of which is often a matter of personal choice. There is no single answer for which languages are used for specific applications. This issue is particularly challenging when HA/DR mapping sites are operated by volunteers. For example, a volunteer helping with the publication of Twitter feeds onto a disaster map may use JavaScript, then use GeoJSON with Flickr and XML with SMS messaging data. Each of these creates multiple GIS layers that are then placed on maps. But by using multiple programming languages, there are opportunities for errors and programming collisions.

Similarly, APIs, which are often written to extract information from one location to be read by an interface, are managed at the discretion of the owners. APIs will often be made available for specific operating systems and may not interoperate across platforms.

Simplified and interoperable application standards for reading and understanding datasets need to be specifically developed for imagery data layers, allowing for open source inputs from various news feeds and application platforms. Examples of some needed standards include keyword index taxonomies and tagging (or

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35 http://www.rssboard.org/rss-specification
36 http://code.google.com/apis/youtube/2.0/developers_guide_protocol.html
37 http://www.opengeospatial.org/standards/gml
38 http://google-latlong.blogspot.com/
39 http://en.wikipedia.org/wiki/Comparison_of_database_tools

hash-tagging, the process of using a hash mark [#] before the word) often used with GPS coordinates. Currently, there is no standard for generating a time stamp identification or user ID (source) for export to a dataset, which gets transcribed onto other application layers such as KML. KML is often the sole source input feed into volunteer syllabus HA/DR data, because there is a large community of developers that use Google Earth for their source of maps and imagery. But there are serious issues with KML. When one portal uses imagery (example Google) and collects data from its own data sources (for example, the KML API version 2), it cannot be reused on a different service provider source of imagery (say Microsoft Bing Maps) because they do not support KML natively. Additionally, the introduction of KML API version 3 creates new technical obstacles with the different programming options available. KML directly links to the original source imagery as it is being served and cannot be interpreted or extracted. This means work is duplicated to export a data set to different APIs made for different image repositories. When supplemental image data is combined on different platforms, this step becomes necessary. One data portal may have updated imagery for Region 1 while a second data portal may have updated imagery for Region 2, but neither has both regions combined. Integrating the data portals requires cycle time between the two service bureaus to enable interaction, which consumes valuable time.

Open standards have been created by the Global Disaster Alert Coordination System (GDACS)[40] in Europe, comprised of policies organized by UN-OCHA to format data that is collected, apply it to HA/DR maps and send out the information to its members. The data is imported and exported using RSS and email notification.

For commonality, WMS is the protocol the majority of service map providers use to layer their geographic reference datasets. Over the past year, a commercial firm in Germany called GeOps[41] created a non-profit organization to determine how well developer's image/maps work to WMS standards. The company currently monitors 270,000 WMS layers published by more than 4,500 worldwide service bureaus.

The Open Geospatial Consortium (OGC)[42] is a voluntary standards body with no specific mandate and has no recognized governance body managing it. The OGC works with associations that adhere to internationally recognized standards groups such as the International Organization for Standardization, Internet Engineering Task Force (IETF) and World Wide Web Consortium, and has compiled roughly 30 different application standards.[43] Adherence to these standards is not required and is often ignored for service delivery reasons.

Commercial Software Applications for Publishing Geographic Information on the Web

- **GeoBase (Telogis GIS software)**
- **PlanAcess**
- **Intergraph GeoMedia WebMap**
- **SeaTrails AtlasAlive**
- **Google Earth and Google Fusion**
- **Smallworld's SIAS**
- **Stratus Connect**
- **ESRI's ArcIMS and ArcGIS Server**
- **ObjectFX**
- **MapServer**
- **GSS –MapXtreme**
- **Cadcorp GeognoSIS**
- **Autodesk Mapguide**
- **ERDAS APOLLO Suite**
- **GeoServer**

[40] http://www.gdacs.org
[41] http://www.mapmatters.org/
[42] http://www.opengeospatial.org/
[43] http://www.opengeospatial.org/standards

Data Management

Options and Obstacles

Although there is a lot of technology designed for use in the field, optimal implementation is not always straightforward. Stakeholders must align their needs collectively and convey them to vendors. Not only must the technical requirements be mutually acceptable, but they must be delivered within cost constraints.

Image technology advances during the past 5 years have created exceptional opportunities through lenses, chipsets (in particular CCDs), software and—in the near future—the ability to take multiple resolution images simultaneously. In particular, digital imagery used with cartographic techniques has enabled new types of maps to be produced that can be densely layered with datasets. The amount of detail that can be extracted from an image has increased more than 100-fold since 2005. This capability has created innovation in the embedding of post-disaster images onto maps in four dimensions: height, width, depth and time.

Images collected from the 2010 Haitian earthquake covered approximately 250 square kilometers (Port Au Prince is 32 square kilometers) from a variety of commercial and government agency service bureaus. In Honshu, Japan, the reconnoitered area was more than 5,000 square kilometers. The section of Miyagi Prefecture where some of the most severe damage occurred required 10 times the amount of imagery as Port-Au-Prince did. For each image, the file size and data that are transcribed and embedded or linked to it require vast quantities of storage. The higher the resolution, the more files to be recorded are required.

Files of such imagery require storage services that scale rapidly into the terabyte size or larger. It should be noted that storage of 10 petaBytes[44] at any one facility constitutes Commercial Data Center classification, requiring maintenance staff, backup power and redundant broadband access services. Data center services are expensive to operate. Additionally, data of this scale and volume requires high performance network access. An example of a global scale mapping effort is Microsoft's Bing mapping product. Every month, imagery updates are loaded onto its servers and each global update is estimated to average about 10 terabytes in size.[45]

Some disaster responders have argued that the ability to browse the Web in the field is undesirable because there is not enough bandwidth to access the data being served remotely, or the bandwidth that would be adequate is prohibitively expensive. Most platforms on the Web host their data with a client-server processing architecture, meaning that the client (in the field) is requesting data hosted on a server. That server will often be located in a different country or even a different hemisphere than where the information is needed. Imagery services may soon develop a standard that enables datasets to be compartmentalized and downloaded with update solutions that only change imagery data defined as required by each ground team.

Data Sharing

The Internet's social capabilities have enabled hundreds of applications to be developed and integrated with imagery, but that doesn't mean they are all useful. Some social data streams are easily available but are difficult to filter, or redundant, or are not informative. However, other datasets are highly valuable but not accessible due to corporate or commercial interests, government policies, or law. Many government agencies further complicate the issue by mandating software that cannot easily parse these data formats. Even when

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[44] 1000 TeraBytes = 1 Petabyte = 10^{15} Bytes / 1 Terabyte = 1,000 Gigabytes. / 1 Gigabyte = 1,000 Megabytes. Storage and file sizes typically are expressed in terms of Bytes in decimal form, while data transmission rates usually are in terms of bits per second (bps). One Byte = 8 bits. Binary formula equates; 1 Megabyte = 1024 kilobytes, 1 Gigabyte = 1024 Megabytes, etc.

[45] http://en.wikipedia.org/wiki/Bing_Maps

governments and commercial entities do share datasets, the terms and conditions are often very strict, or they are only available through a proprietary API and not downloadable to other network data storage facilities. Copyright infringement, licensing rights, privacy regulations and proprietary data limits are additional roadblocks to sharing data.

The most serious issues overlooked involve liability protections by both the publishers and sources of imagery and its data. As far as our research shows there is no universally adopted Good Samaritan law that can protect volunteers who translate emergency help messages, map them and distribute that map to response teams in the field.

Another rising concern is who owns the finished product when data sources are published and used. Many non-profit organizations do have Creative Commons license[46] terms and conditions that waive any proprietary rights. Commercial use agreements for software such as Google Earth, Google Maps[47] and Microsoft Maps[48] should be reviewed with legal counsel to understand content rights, distribution restrictions and other limitations.

The Need for Data Interoperability

Developers using APIs know that not all user devices (browsers, netbooks, tablets, smart phones) are compatible with their interface tools. Users need to be aware that APIs are constantly being upgraded and that upgraded code may affect the API's performance on their device. As these APIs improve, backwards compatibility becomes an obstacle to end user device capability. Google's API, now available as API Version 3,[49] is compatible with modern smart phones, where previous versions were not. The mobile version 3 is a lightweight (small—32 kilobytes (KB) per tile) JavaScript design, enabling these devices to work within acceptable operating parameters. As in all software development and vendor solutions, long-term support for these APIs create some obvious concerns. Google plans to support Version 2 of the API until 2013. Microsoft offers an API available in its SDK for Microsoft Bing Maps.[50] However, the ability to interoperate or integrate with KML is not easily accomplished. The need for consistent interoperability is clear, but it's a recurrent problem in many software services and not unique to mapping.

Collaborative efforts to add data layers to imagery are a priority for both public and private entities. The U.S. Government has created a website on the topic, centered on the use of XML[51] when integrating data supplied by Government agencies. Options offer opportunities, but also risks conflict, errors and confusion. Single-use image production not exportable to other portals during a disaster event creates a regrettable demand for multiple sets of imagery, and thus extra service and processing, plus added data downloads by end users. This creates congested networks and increased storage requirements.

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46 http://creativecommons.org/
47 http://maps.google.com/help/terms_maps.html
48 http://www.microsoft.com/maps/product/terms.html
49 http://code.google.com/apis/maps/documentation/javascript/reference.html
50 http://www.microsoft.com/maps/developers/mapapps.aspx
51 http://xml.gov/

Standards for Cartography and GIS datasets

GDACS retrieves open source or non-restricted data by subscribing to RSS texts from a variety of sources and places them onto open source maps that UN-OCHA[52] created to help solve several problems in HA/DR response.

The most commonly used map projection used in HA/DR mapping is the World Geodetic System (WGS). A projection is a transformation of the spherical or ellipsoid earth onto a flat map. There are many different projections that can be chosen to preserve the area, shape or distance computations from the sphere to the planar representation of a region. In order to take data from one projection and overlay it on a dataset with a different projection, a transformation must be performed on the data that warps the original data into the new projection. Every time data is projected or transformed into a new projection, the accuracy and precision of the original data is compromised. Prior to 1958, there were several different projections commonly used for charting and publishing maps. A singular global map standard began with WGS60 (1960), updated in 1980 as Geodetic Reference System 80, which evolved into the WGS84 standard in 1984. With these standards, maps were published with common reference points regardless of the scale or size of the map. Its adoption offered information layering opportunities that could be transferable from one source reference map to another with no errors. WGS84 has been updated to the Earth Gravitational Model(EGM)96. The United States Geological Survey (USGS) uses WGS84 when mapping an earthquake's epicenter and publishing location data.[53]

Open Source Map resources

Open source applications exist, and enable developers to create new maps that layer over satellite imagery. It is important to note that when using open source maps or layers, there is no specific support or real-time capability to troubleshoot any issues that may occur. The advantage to using open source maps as a foundation is the speed with which you can add data and the lack of legal copyright considerations. Since 2004, OSM[54] has been a pioneer in cartography and in the visualization of crisis mapping and continues to drive new innovative technology concepts. OSM natively uses Openlayers Java.[55]

There are several sources of open source cartography. With these maps, satellite imagery can be overlaid using open standard software and APIs. Some commercial vendors have accepted this standard and allow these services to embed open source maps onto their devices. Garmin offers the ability to layer your own map[56] images onto several different models. Table 1 shows a few of the open source map providers registered in the second quarter of 2011.

Table 1. Open Source Map Providers Registered in the Second Quarter of 2011

Map	Theme	Area
OpenStreetMap	general, cyclists, debugging	Worldwide
Information Freeway	general, almost real-time	Worldwide
OSM WMS Servers	general, Web map services	Worldwide
OpenSeaMap	nautical chart	Worldwide, multilingual: seas, oceans and waterways
OpenStreetBrowser	features highlighting	Europe
FreeMap	Walkers	parts of the United Kingdom

52 http://www.reliefweb.int/
53 http://earthquake.usgs.gov/earthquakes/glossary.php#location
54 http://www.openstreetmap.org/
55 http://www.openlayers.org/
56 http://wiki.openstreetmap.org/wiki/OSM_Map_On_Garmin

Reit- und Wanderkarte	walkers and riders	Austria, Germany, Switzerland
TopOSM	walkers and riders	United States
OpenCycleMap	Cyclists	Worldwide
YourNavigation	Routing	Worldwide
OpenRouteService	Routing	Europe
OpenOrienteeringMap	orienteering style	Worldwide
OpenPisteMap	Skiing	some European and USA resorts
Bing OSM "Map App"	General	Worldwide
CloudMade	general, mobile and various other custom styles	Worldwide
OpenAviationMap	Airspace indexing and classification	Braunschweig, Germany
MapQuest Open (beta)	general, routing	Worldwide
NearMap	up-to-date photomaps	populated areas of Australia
OSMTransport	public transport	Worldwide
ÖPNV-Karte, or OpenBusMap	Public transport	Europe
OSM Mapper	Debugging maps by Ito World Ltd	
Busroutes.in	Public transport bus routes	India (Chennai) [Bangalore and Delhi under development stage]

Source: Wikipedia[57]

Hardware

The Data Center

The power of imagery brings a self-inflicted Achilles' heel injury that is hard to overcome. The sheer volume of imagery available is becoming untenable for a variety of users and agencies, which is why it is now as important to consider where the data is archived as it is to consider how to process it. The volume of storage space required to house satellite and aerial image data now demands professional data center facilities, which quickly becomes an accessibility problem. Reach back facilities that are out of harm's way can provide high speed access (10 gigabits per second [Gbps] and higher), but end up being retrievable at only 1 megabit per second to those on the ground. Delivery of these modified resources to the field is a critical issue and can impact how, when and where users retrieve files.

Users can cache files on traditional devices such as laptops, notebooks and some tablets, while first-generation smart phones have limited capacity and current generation tablets can store up to 64 gigabytes (GBs) (iPad 2). Google Earth for personal computers (PCs) and Mac computers can cache up to 2 Gigabytes of data natively before a call to a data center to load image files is required. There is no easy way to know how much of this cache is dedicated to global mapping files versus updating imagery that is downloaded. This caching feature does not cache KML or KMZ files (*KMZs* are collections of KML files compressed into single file) if the files do not include the images within the KML container, which most do not. There are free geographic tools that assist users in creating customized cache settings and files. However, as Google Earth updates its application, there is no guarantee that customized cache settings and files will continue to work. The tools do not have a bypass capability to exceed Google Earth's 2 Gigabyte caching limit.[58] This illustrates the need for data server access to be near to the disaster zone if intense imagery file retrieval and regular updates are required. It should

[57] http://en.wikipedia.org/wiki/OpenStreetMap
[58] http://freegeographytools.com/2009/automating-the-google-earth-caching-process

be understood that Google Earth (and other similar programs) were never intended for HA/DR use. Google's disaster response team recognizes these severe shortfalls and is changing both data center policy and hardware constraints because of it.

There are methods that can be used to get high volume image datasets on the ground faster; an example includes the Map in a Box.

Moving the Data Center: Using a Map in a Box Solution

Data center mobility should be a key next-generation requirement to provide accessibility to imagery in the field. The goal should be to ensure that large image data and associated datasets can be made available as close to the disaster event as possible, saving valuable network connectivity to other critical application services such as Voice over IP and real-time situation awareness needs. Reach back and forward operating access to large data storage facilities should be a priority for government and private institutions offering these services.

It is therefore recommended that a mobile data storage system be considered early in a response. The processing capacity and data storage (hard drive space) should be sufficient to contain enough imagery to hold the pre-event and post-event aerial and satellite imagery with ancillary digital open source maps and ancillary applications required to cover a forward operating area of a disaster site. It should also contain two Ethernet 1-GB network cards for network access. The parameters of HA/DR forward operating headquarters should be defined by NGOs, IOs, and government agencies to determine which groups are responsible for which geographic areas, and that will determine the mobile storage system requirements. An example is Port-au-Prince. Pre- and post-event imagery covering every square inch of the city would require approximately 24 terabytes of data storage requiring approximately 3 compact devices and 1 optional network processing server which can also host mapping software if required. Each unit consumes approximately 82 watts of power at its maximum operating performance. This system would be connected to multi-stacked Ethernet switches for local high speed local area network access and Wi-Fi Access Points. These systems can be configured to be networking-neutral for easy access by Apple, PC Windows, and Linux computers. They can also be made available with expanded memory cards with secure digital (SD) and micro SD slots. This allows the quick transfer of data onto memory cards (and vice versa), which can subsequently be transferred into smart phones through micro SD memory cards or tablet computers though SD memory cards.

Updates to satellite imagery can be processed with open standard GIS metadata on hot swappable hard drives and can be delivered through the normal course of resupply that occurs at the forward operating headquarters. The hot swappable drives can replace or be added to additional files, be quickly installed into these units, and be instantly made available to users on the network. The economics of supplying imagery updates in this manner is likely to be more cost effective than consuming expensive satellite or mobile phone bandwidth and avoids congesting these networks unnecessarily.

For mapping applications to work with a Map in a Box configuration, settings for files storage locations need to be configurable by the user. In addition, new or upgraded APIs may be required or new Java-based scripts must be designed. This was prototyped during the Strong Angel III HA/DR demonstration in San Diego in 2006 and worked very well. The level of computer performance and capabilities are superior today to what was available then.

Mobile Smart Devices: Situational Awareness for Humanitarian Responders and the General Public

Mobile devices such as tablets and mobile phones are now the primary mode for both collecting and sharing information in a response effort. A January 2011 report published by the Mobile Computing Promotion Consortium of Japan surveyed users of smart phones. Of those who had smart phones, 55 percent used a map application, the third most common application after Web browsing and email.[59]

Android and iPhones both support Google Maps while Windows phones use Bing maps. Motorola offers the ability to use Google or Microsoft, depending on which operating system is installed on the device. MapBox, a custom map application on the Web, has created an application for Apple's iPad 2.[60] Some telecommunications providers prepackage imagery options on these devices with embedded software. Others have exclusive software add-on contracts that may not offer alternatives to be installed on the device when operated on that mobile carrier's network (figure 3 shows a map application on an iPAD.) The ability to overlay information on these mapping applications with any utility varies by manufacturer. For example, some map applications on smart phones do not recognize KML layers. In addition, not all wireless phone operating systems are compatible with the application foundation platform, such as Google Maps or Google Earth, and in fact may only be compliant with a competitor's proprietary version creating further export challenges. Also, smart phones vary by operating system, software ecosystem, application capabilities, memory capacity, network speed and energy consumption. Other variations in mobile phone compatibility are SMS character limits, MMS compatibility and other third-party extensions like GPS location services. Smartphone browser options vary as well. Some have their own native Web browser, and others use downloadable versions. Not all browsers support add-on plug-ins such as Java,[61] Adobe Shockwave,[62] Flash or KML[63] layers (based on Java) or other specialized software apps.

To deliver imagery to every platform generates redundant cycles of content delivery, increasing costs and potential delays in publishing critical information. There are no international standards for devices, applications or hardware for HA/DR service delivery and, like public emergency telephone usage, standards vary around the world.[64]

Because of the application limitations, developers have created workarounds for a variety of smartphone devices by "jail breaking" the devices away from their registered cell service provider. There is significant risk in doing so, including the manufacturer remotely "bricking" the device due to legal software agreements a user signs at the time of purchase. *Bricking* a device is a process that completely disables the device from operating and it is extremely difficult to repair or undue.[65] The Electronic Frontier Foundation claims that it is legal to jailbreak a device and the question is currently before the courts.[66]

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[59] http://www.mcpc-jp.org/english/pdf/20110128_e.pdf
[60] http://mapbox.com/#/
[61] http://www.java.com/
[62] http://www.shockwave.com/
[63] http://code.google.com/apis/kml/documentation/
[64] http://en.wikipedia.org/wiki/Emergency_telephone_number#Emergency_numbers
[65] http://en.wikipedia.org/wiki/Bricking
[66] http://www.eff.org/press/archives/2010/07/26

In February 2009, Apple filed a patent that enables users to be identified when jailbreaking its devices, including iPhones, iPods, and iPads.[67] Research in Motion's (RIM's) Blackberry devices that are capable of using the AT&T network to tether have software workarounds that are also under scrutiny.[68]

Telecommunications carriers are also monitoring modified smartphones that are operating on their networks. Several carriers have broadcasted to their customers that any modified (*jailbroken*) smart device will be disabled if found operating on their network.[69]

It is therefore critical that imagery services consider how this information is best served to the widest user audience possible without creating multiple duplications of layer imagery. An important consideration is battery consumption in these devices. As device processing power demands increase, the faster the device consumes power, requiring frequent recharging, which in itself is a limited resource.

For context, it should be noted that during the Miyagi Earthquake and Tsunami of March 2011, comScore found that 93 percent of all mobile phone users in the impacted region were not smartphone service capable.[70] In response, Google created multiple viewing options for the same data.

Smartphone manufactures are not aligned to a single source of mapping technology and their operating systems do not always offer third party application plug-ins.

The Smartphone Global Market Share

Table 2. Top Five Smartphone Vendors, Shipments, and Market Share During the Fourth Quarter of 2010 (Units in Millions) [71]

Vendor	4Q10 Units Shipped	4Q10 Market Share	4Q09 Units Shipped	4Q09 Market Share	Year-over-year Growth
Nokia	28.3	28.0%	20.8	38.6%	36.1%
Apple	16.2	16.1%	8.7	16.1%	86.2%
Research In Motion	14.6	14.5%	10.7	19.9%	36.4%
Samsung	9.7	9.6%	1.8	3.3%	438.9%
HTC	8.6	8.5%	2.4	4.5%	258.3%
Others	23.5	23.3%	9.5	17.6%	147.4%
Total	100.9	100.0%	53.9	100.0%	87.2%

Table 3. Top Five Smartphone Vendors, Shipments, and Market Share, 2010 (Units in Millions)[72]

Vendor	2010 Units Shipped	2010 Market Share	2009 Units Shipped	2009 Market Share	Year-over-year Growth
Nokia	100.3	33.1%	67.7	39.0%	48.2%
Research In Motion	48.8	16.1%	34.5	19.9%	41.4%
Apple	47.5	15.7%	25.1	14.5%	89.2%

[67] http://www.patentvest.com/console/reports/docs/app/20100207721.html
[68] http://crackberry.com/att-blackberry-bridge-download
[69] http://www.tipb.com/2011/03/18/att-cracking-jailbroken-mywi-users/
[70] http://www.comscore.com/jpn/Press_Events/Press_Releases/2011/2/Smartphone_Adoption_Continues_to_Grow_in_Japan
[71] Source: IDC Worldwide Quarterly Mobile Phone Tracker, January 27, 2011.
[72] IDC - http://www.idc.com/about/viewpressrelease.jsp?containerId=prUS22689111

Samsung	23	7.6%	5.5	3.2%	318.2%
HTC	21.5	7.1%	8.1	4.7%	165.4%
Others	61.5	20.3%	32.6	18.8%	88.7%
Total	302.6	100.0%	173.5	100.0%	74.4%

Smartphones to Smart Tablets

Smartphone and smart tablet technology offer advanced capabilities and uses for the HA/DR community. Tablet computing, once thought to be a small consumer market segment, has exploded with the launch of Apple's iPad.[73] The second generation release in 2011 created new market innovations in browsing information and computing power. Competitors have launched new products because of Apple's tablet success.

Table 4.[74] Global Shipments of tablet operating systems (os)

Shipping Period	Q3 '10	Q4 '10	2010
Apple iOS	4.2	7.3	14.8
Android	0.1	2.1	2.3
Others	0.1	0.3	0.5
Total	4.4	9.7	17.6

Table 5. Global Tablet Operating System Marketshare (%)

Evaluation Period	Q3 '10	Q4 '10	2010
Apple iOS	95.5%	75.3%	84.1%
Android	2.3%	21.6%	13.1%
Others	2.3%	3.1%	2.8%
Total	100.0%	100.0%	100.0%

The three key breakthroughs in tablet developments are battery life, graphics and small form factor A5 processors. The device claims to have up to 10 hours of operating capability before recharging is required. Apple's iPad 2 is available with tri-mode network connectivity. This enhances the users' ability to connect to a variety of communications networks that include Wi-Fi and third generation (3G) in code division multiple access (CDMA)[75] or Global System Mobile (GSM)[76] modes. With the added performance advantage of large solid-state disk space, large software ecosystem performance is greatly enhanced. Google's Android open source software approach expands imagery applications opportunities that may be otherwise confined. Software designed for Blackberry's new Playbook will run Android apps and connect with all Wi-Fi standards and next generation wireless long term evolution (LTE) and high-speed packet service (HSPA)+ network protocols.[77]

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[73] http://www.apple.com/ipad/

[74] Source: Strategy Analytics

[75] Code division multiple access - http://en.wikipedia.org/wiki/Code_division_multiple_access
http://www.cdg.org/

[76] Global System for Mobile Communications - http://en.wikipedia.org/wiki/Global_System_for_Mobile_Communications
http://www.gsmworld.com/

[77] BlackBerry PlayBook with Wi-Fi 802.11 a/b/g/n
BlackBerry 4G PlayBook with Wi-Fi 802.11 a/b/g/n + WiMax
BlackBerry 4G PlayBook with Wi-Fi 802.11 a/b/g/n + LTE
BlackBerry 4G PlayBook with Wi-Fi 802.11 a/b/g/n + HSPA+
http://us.blackberry.com/playbook-tablet/?IID=us:bb:homepage_Learn%20more

As these devices become part of the social fabric, Global CDMA[78] and GSM smart phones with map applications are becoming available[79] and should offer the ability to accept and view layered maps for HA/DR teams in conjunction with post event imagery to solve situational awareness for possible communications infrastructure damage. The acquisition of this technology will initially be adopted by well funded NGOs and public safety agencies. It remains to be seen if such technology can cascade to smaller NGOs and government public safety agencies that have very long IT replacement cycles. Adoption in regions like Africa, Southeast Asia and South America may use low cost versions by smaller vendors and may not be compatible with name-brand applications and may have limited network connectivity options.

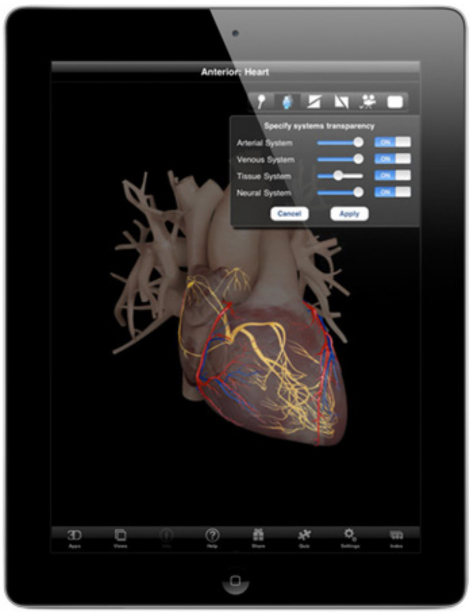

Figure 2. iPad with Health Pro software image[80]

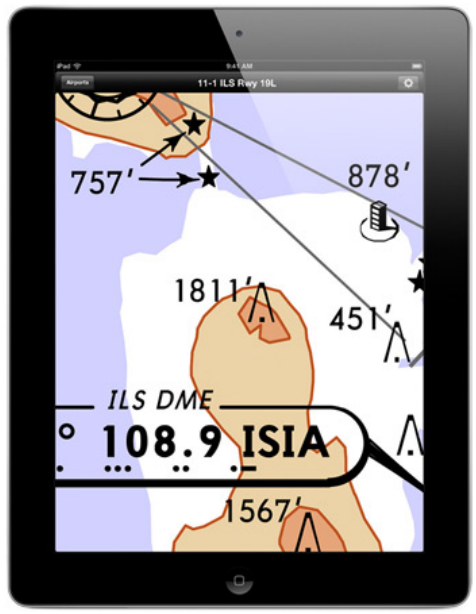

Figure 3. iPad with Jeppesen map[81]

[78] http://www.cdg.org/worldwide/index.asp
[79] http://www.mobileworldlive.com/maps/
[80] http://www.apple.com/ipad/
[81] http://www.apple.com/ipad/

Figure 4. Blackberry Playbook by RIM[82]

The tablet market was once thought to be a specialized market segment used for unique applications and services. The idea was to use it for logistical applications such as medical and marketing surveys. No longer is this the case as Apple has proven with the launch of the iPad 2, selling approximately 400,000 units in 26 countries within 3 days.[83] RIM's launch of the Playbook (above) integrates with Android apps,[84] offering thousands of applications written for Android. RIM's foray into the tablet market is clear recognition that these devices are a large segment of the "Smart" telephony and Internet access market. By offering features similar to Apple and Motorola, the device offers rich graphics capability in addition to long battery life with wireless high-speed access including LTE and HSPA+. It is important to note that these devices offer critical advantages over smaller form factors. Among them are interchangeable keyboard formats for language, large screens for Web applications (such as Google language translator) and advanced graphics processing enabling the use of satellite imagery to be viewed in the user's desired resolution. A key feature is that it can tether via Bluetooth to an existing Blackberry smartphone to use its network connectivity. If network connectivity survives a disaster, these devices will play an important role in HA/DR responses anywhere services are operational. With advanced cellular on wheels emergency communications platforms available in a variety of configurations, repair times are reduced (see section V, communications networks.)

[82] http://ca.blackberry.com/playbook-tablet/
[83] http://online.wsj.com/article/SB10001424052748704027504576198832667732862.html
[84] https://market.android.com/

Figure 5. Motorola Xoom **Figure 6. Samsung Galaxy**

Every major manufacturer now has a tablet model either in the development pipeline or entering service. This includes Motorola (Xoom with Android)[85] selling more than 100,000 units (figure 5), as well as the Samsung Galaxy, which is selling well (figure 6). Verizon is offering CDMA–Wi-Fi/LTE network connectivity.[86] Samsung offers the Galaxy[87] tablet available in two different screen sizes and it is also available with Wi-Fi/HSPA+ connectivity. LTE and HSPA+ are capable of downloading at speeds of 22 megabits per second (Mbps.) All claim to have more than 10 hours of battery life when network connectivity is enabled. Other manufactures such as Dell, Hewlett Packard, LG, and Viewsonic have thin-profile devices available in 7 inches and larger sizes. The cost of these units ranges from $300 to $950 (U.S.).

[85] http://www.motorola.com/Consumers/US-EN/Consumer-Product-and-Services/Tablets/ci.MOTOROLA-XOOM-US-EN.overview
[86] http://www.motorola.com/Consumers/US-EN/Consumer-Product-and-Services/Tablets/ci.MOTOROLA-XOOM-US-EN.alt
[87] http://www.samsung.com/global/microsite/galaxytab/

V. Communications Networks

Communications networks, including satellite, terrestrial wireless, and landline voice/data network links, are vital to transmitting all forms of information to decisionmakers for analysis and action. Imagery has become a cornerstone of factual information for disaster response and requires capable communication networks to be shared. The explosive growth in telecommunication technology, networks, and devices has created new applications within individual and group communities influencing consumer behaviors, business operations, and volunteerism. These tools are driving network providers to develop faster network access services. Hardware vendors are following suit with powerful handheld devices that rival regular desktop computers. Data is becoming accessible to those who need it.

Mobile Network Services

There are three different technologies that are used for terrestrial-based mobile networks. Terrestrial-based wireless technologies include GSM, CDMA and Universal Mobile Telecommunications System (UMTS). GSM is used worldwide while CDMA is generally focused in North America, Japan, China, and India.[88] UMTS networks are deployed in North America, Japan, Southeast Asia, Europe and Africa. Each has next generation high-speed data network capabilities including 3G, fourth generation, HSPA+[89] and LTE. Over the next several years, these technology platforms may be paired down to two competing standards, GSM/EDGE and Wide Code Division Multiple Access (W−CDMA)/LTE/UMTS, although this forecast is not certain given the constantly changing market and nature of the industry. Wireless access technologies are now capable of delivering true high-speed broadband service to mobile phone devices; in particular, smartphone hardware is equipped with next generation chipsets. Ten years ago, the average mobile user connected at 14,400 to 28,800 Kb per second. Today, smartphones can connect at speeds exceeding 20 Mbps with higher speeds becoming available within the next 3 years.

Global System Mobile (GSM)

The most popular mobile network solution used worldwide is the GSM technology platform with a follow on system called EDGE (Enhanced Data GSM Evolution). The technology is continually evolving as shown in figure 7. GSM uses time division multiple access limiting its maximum range to approximately 35 kilometers from a tower, assuming ideal conditions are available.[90] It is possible to extend the range up to 120 kilometers.[91]

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[88] http://en.wikipedia.org/wiki/List_of_mobile_network_operators
[89] High Speed Packet Service - http://www.gsacom.com/news/gsa_319.php4
[90] http://www.allbusiness.com/electronics/computer-electronics-manufacturing/6838169-1.html
[91] http://www.allbusiness.com/electronics/computer-electronics-manufacturing/6838169-1.html

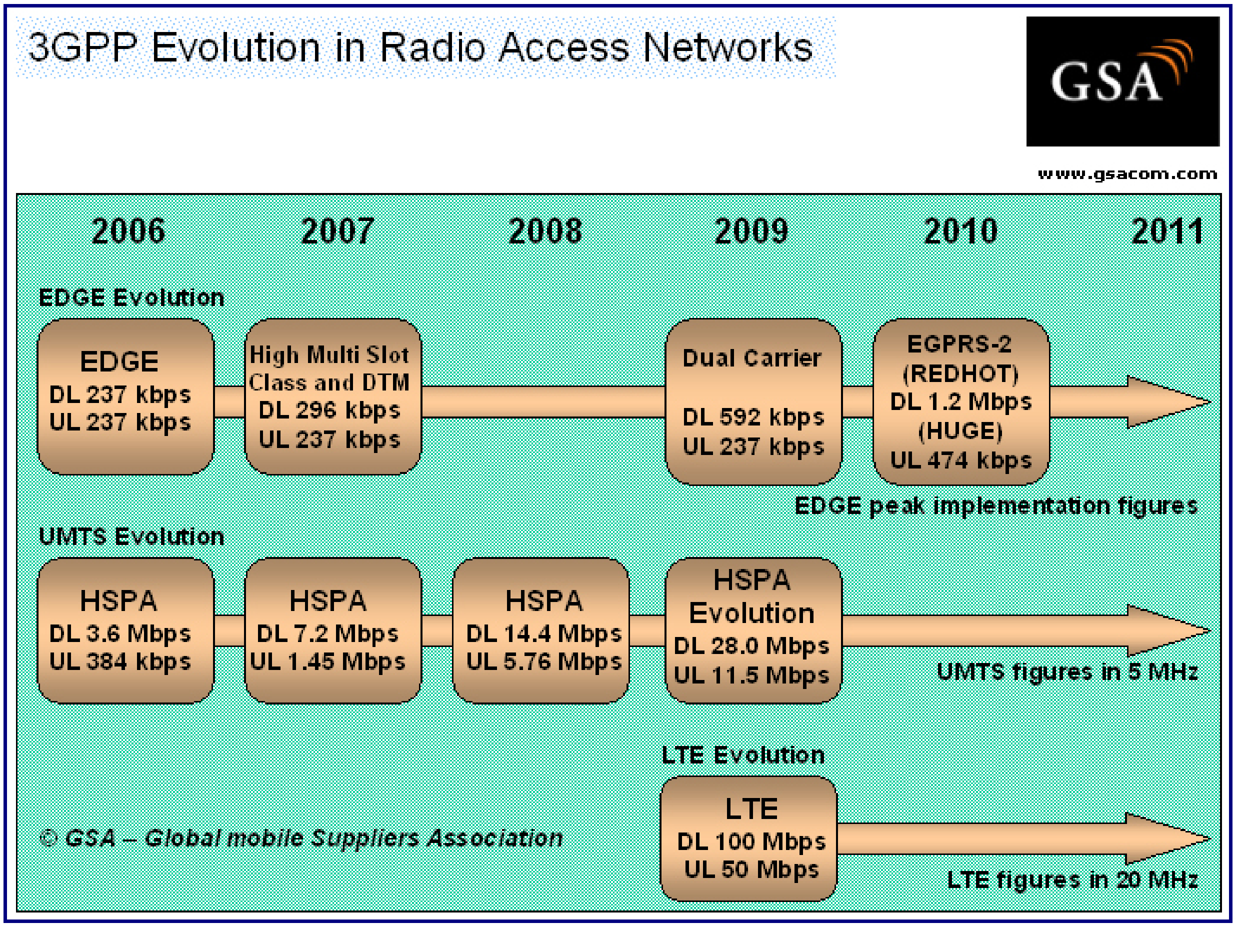

Figure 7. GSM and UMTS Product Roadmap Illustrating Data Download Speeds[92] (data from the 3rd Generation Partnership Project – 3 GPP)

Code Division Multiple Access (CDMA)

The range of a mobile network depends on the frequencies used. In 2008, more than 180 CDMA mobile carriers announced network upgrades to W-CDMA.[93] Backwards compatibility will be maintained for the foreseeable future. In 2010, the evolution continued with the addition of LTE. Overall CDMA will continue to be supported for years to come. However, as devices migrate to next generation standards, use of generic first-generation CDMA will be gradually discontinued. This will allow for more efficient use of the wireless carrier spectrum, which currently uses it.

Universal Mobile Telecommunications System (UMTS)

UMTS is primarily used in Europe. One of the drawbacks first generation UMTS/EDGE handsets currently experience is higher power consumption levels when compared to GSM or CDMA service. These devices are still in wide use and production today. W−CDMA and UMTS can be interoperable, roaming between different mobile network operator customers if the handset is a dual mode model. Handset manufactures offer dual, tri-mode, and quad-mode phones.

[92] http://www.gsacom.com/news/statistics.php4
[93] http://www.cellular-news.com/story/34083.php

Wide Code Division Multiple Access (W−CDMA)

Japan's largest mobile network is based on W−CDMA technology and has essentially the same structure as UMTS.

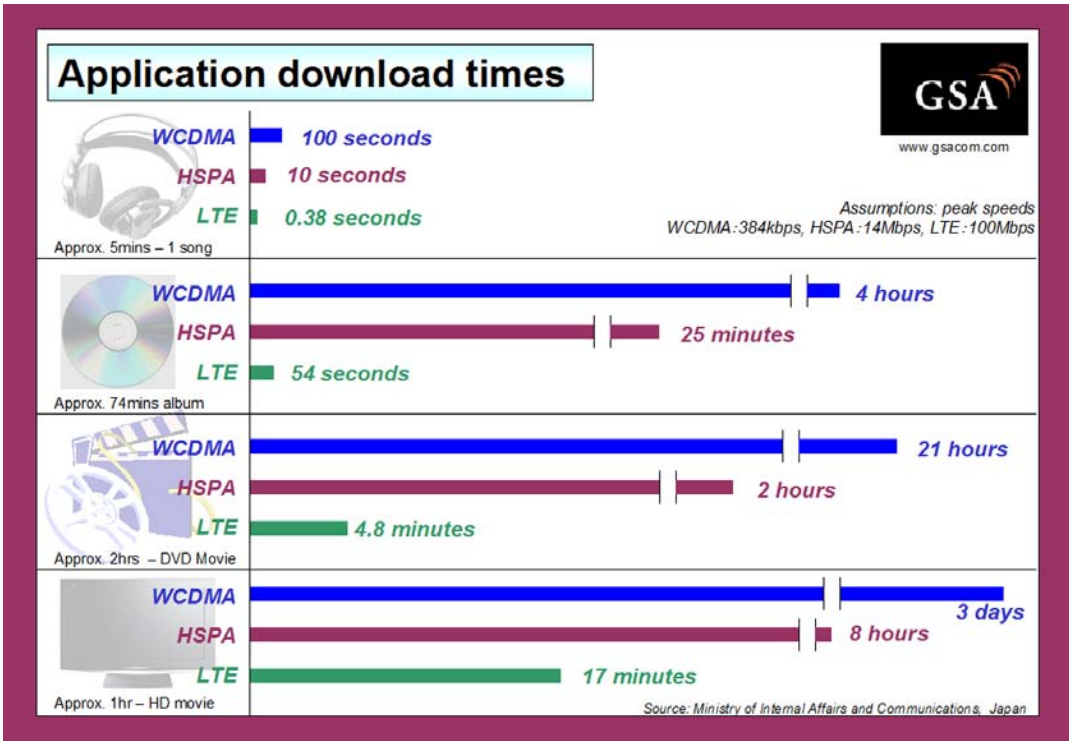

Figure 8. Comparison of Bandwidth Speeds[94]

Figure 8 shows the time needed to download different kinds of popular applications (songs, albums, DVD movies, HD Movies) under different communication technologies. Actual times vary based on the wireless carriers infrastructure backbone, tower capacity and investments made in the network architecture.

[94] http://www.gsacom.com/news/statistics.php4

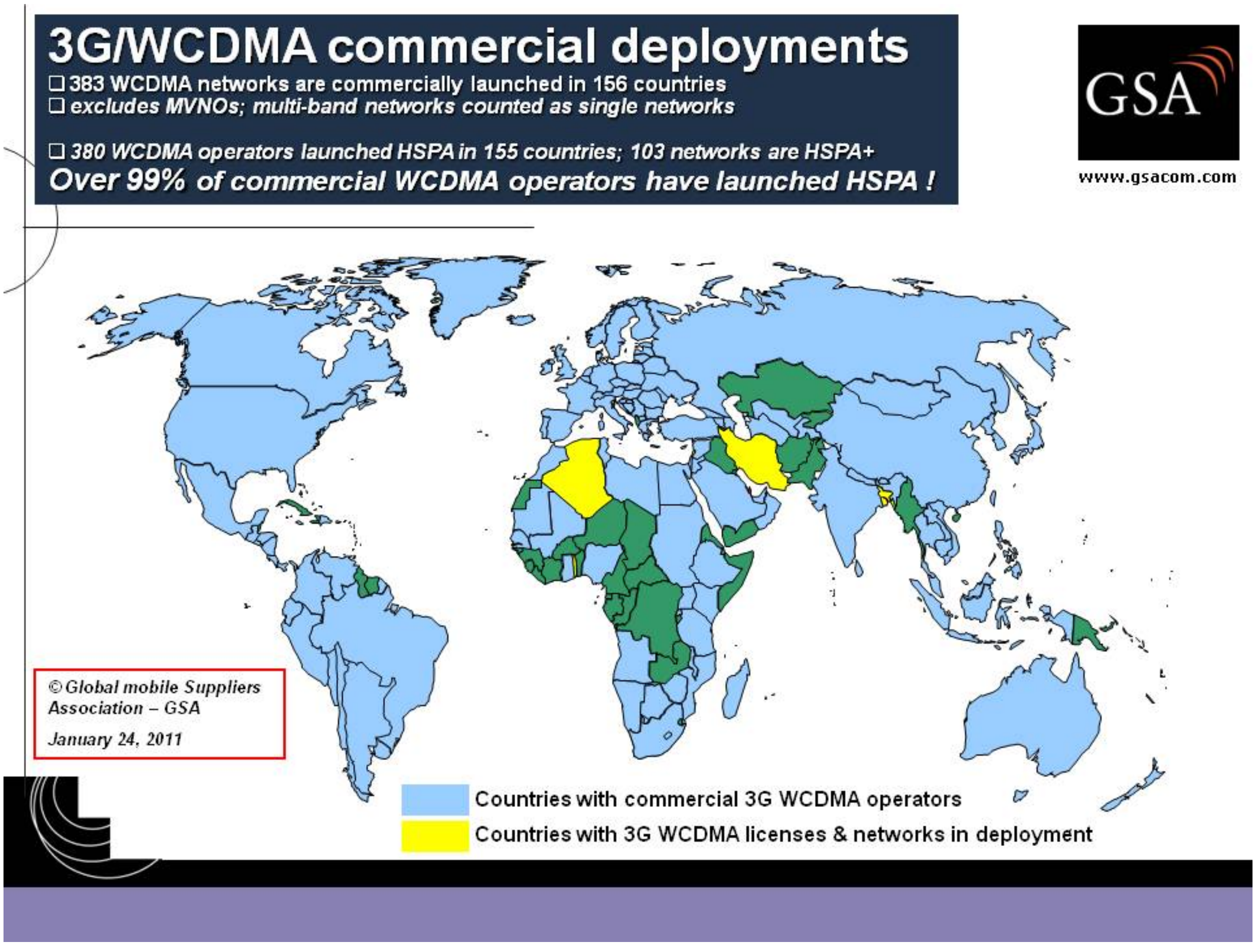

Figure 9. Coverage Map 3G Illustrating W−CDMA and UMTS Coverage with HSPA Availability[95]

Wireless Resiliency

In the 2004 Banda Aceh 9.3 earthquake and tsunami that killed 250,000 people, 60 percent of all mobile towers in the region were destroyed leaving no CDMA mobile data and only partial GSM capacity (although SMS texting using analog transmission was still able to get through.) Repairs took more than a year to complete.[96] In some areas, 80 to 90 percent of all landlines were damaged or destroyed.[97]

Cellular on Wheels

Mobile wireless telecommunications carriers now provide mobile cellular tower systems that can be brought to a site to augment or replace damaged communications infrastructure and have it operating in several hours, depending on environmental conditions.

The January 2010 7.0 Haitian earthquake killed more than 200,000 people and took a terrible toll on infrastructure. Only three cellular base stations survived.[98] However, within 6 months the system was fully operational to pre-quake service levels. The September 2010 7.1 Christchurch earthquake took down 24 cell

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95 http://www.gsacom.com/news/statistics.php4
96 http://www.kuna.net.kw/ArticleDetails.aspx?language=en&id=1500693
97 http://www.kuna.net.kw/ArticleDetails.aspx?language=en&id=1500693
- Author liaison with PT Telkom counterpart while employed with Bell Canada 2004.
98 http://www.digicelgroup.com/en/media-center/press-releases/achievements/digicel-update-on-situation-in-haiti

sites—almost all of the local system.[99] More were damaged in the 6.3 aftershock. On both occasions, Cellular on Wheels (COW) mobile systems were brought to Christchurch, augmenting service within 7 days.

A major concern was fuel for generating power at the cell sites; the task was assigned priority by the New Zealand government. Several base stations were not damaged but simply lacked emergency diesel fuel replenishment. Service was augmented as the delivery of fuel became available and reduced the load on the towers that were still connected to the power grid.

Table 6. Dependency of Frequency on Coverage Area of One Cell of a CDMA2000 Network. [100]

Frequency (megahertz)	Cell radius (km)	Cell area (km2)	Relative Cell Count
450	48.9	7521	1
950	26.9	2269	3.3
1800	14.0	618	12.2
2100	12.0	449	16.2

In table 6, note that the higher the frequency used, the shorter the radius of support becomes and the number of cell towers increases. The lower the frequency, the less data bandwidth is available to share across users to connect to that cell.

Figure 10. Traditional Mobile Base station[101]

Figure 11. Alcatel-Lucent–Light Radio[102]

The rapid deployment of cellular on wheels is dramatically improving. The Alcatel-Lucent Light Radio is 300 grams (about 10 ounces) and stackable. It also consumes very little power, eliminating large generation and storage requirements. It is can operate on solar, wind and/or battery power. Each cube fits into the size of a human hand and is fully integrated with radio processing, antenna, transmission, and software management of frequency. The device can operate on multiple frequencies simultaneously and work with existing infrastructure.[103]

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[99] http://tvnz.co.nz/national-news/request-limit-use-cellphones-3759932
[100] http://en.wikipedia.org/wiki/CDMA2000
[101] http://net-trixsolutions.com/images/base%20station.gif
[102] http://www2.alcatel-lucent.com/blogs/corporate/2011/02/no-mobile-gridlock-universal-coverage-lightradio-saves-the-mobile-industry-billions/
[103] http://www.youtube.com/watch?feature=player_embedded&v=I7QnGkKlwBw Tod Sizer – Bell Labs / Alcatel - Lucent

Space-based Network Services

When terrestrial-based wireless networks are severely damaged, satellite data systems are the only way voice and data connectivity can be deployed in the field. Small and large form factor satellite-based equipment is used in HA/DR environments. Depending on the scale of the disaster, these resources can be shared by many organizations or deployed in the field to small teams remote from their forward operating headquarters. Telecommunications satellites are positioned at different altitudes in orbits and vary in capabilities and performance.[104] The three primary space-based network architectures are broadband global area network (BGAN), satellite data service and the Kizuna Demonstration Satellite, which is optimized for emergency voice and data communications.

Broadband Global Area Network (BGAN)

BGAN by Inmarsat has delivered Internet and voice services on three geosynchronous low earth orbiting Immarsat−4 satellites covering 95 percent of the Earth's land mass since 2005. They are quick and easy to configure and consume very little power. The hardware required on the ground is available in rugged form factors and offer speeds between 56 Kb and 1 mega bit per second. Once deployed, BGAN network equipment can be connected to Wi-Fi access points to enable users nearby to share the resource. BGAN technology was widely used for the communications during the 2010 Haitian earthquake.[105] In 2010, Inmarsat began construction of a new constellation of Ka band[106] satellites. The Inmarsat-5 constellation will be capable of delivering 50 Mbps.[107]

Satellite Communications

Traditional satellite data service—such as a very small aperture terminal—continues to be a popular option for communications for many large organizations when a disaster strikes. The ground equipment is large in size, requires significant amounts of power and requires certified specialists to set up and configure the equipment. The advantage these systems offer is bandwidth performance ranging from 1 to 50 Mbps. The majority of television news networks use these systems to encode video with high resolution and low latency between the remote location and their broadcast headquarters. Some NGOs and IOs use these systems and deploy them depending on the scale of the event.

In the summer of 2007, Greg Wyler founded a company named O3B (Other 3 Billion) with its primary goal of establishing Internet broadband access in under-developed countries in Africa and South America and in sparsely populated island nations. Wyler has convinced several large corporations to help underwrite the project, including Google, Paul Allen and eight venture capital firms.[108] His goal is to launch a constellation of Ka band satellites with parabolic and maneuverable antennas in a geostationary orbit with bandwidth speeds in the Gbps. No launch dates have been confirmed.[109] Satellites built with directional capabilities would offer significant value to HA/DR communities in underserved regions when disasters strike and be a significant achievement. NGOs would be able to retrieve imagery and all its ancillary metadata more efficiently than with any current technology.

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[104] http://gcmd.nasa.gov/User/suppguide/platforms/orbit.html
[105] http://www.inmarsat.com/Downloads/English/BGAN/collateral/Haitiwhitepaper.pdf?language=EN&textonly=False
[106] http://en.wikipedia.org/wiki/Ka_band . Ku is the other frequency band used on data capable orbiting satellites.
[107] http://www.inmarsat.com/About/Our_satellites/default.aspx?language=EN&textonly=False
[108] http://www.o3bnetworks.com/AboutUs/about_us.html
[109] http://www.o3bnetworks.com/AboutUs/faq.html

Kizuna Demonstration Satellite

In the spring of 2008, the Japanese Aerospace Exploration Agency (JAXA) launched the Ka band Kizuna Demonstration Satellite. It is capable of a 1.2 Gbps Internet Protocol (I.P.) data transmission. A user has the ability to download data at 155 Mbps and upload at 6 Mbps with a 45 centimeter antenna, and they have access to the full 1.2 Gbps by installing a 5-meter (15-foot) antenna.[110] One of its primary goals is serving as an emergency data communications bridge across Japan and parts of Southeast Asia during a disaster. Kizuna is a demonstration platform and it is not known if JAXA will commission this platform as a continuing service. To date, all of its objectives have been achieved.

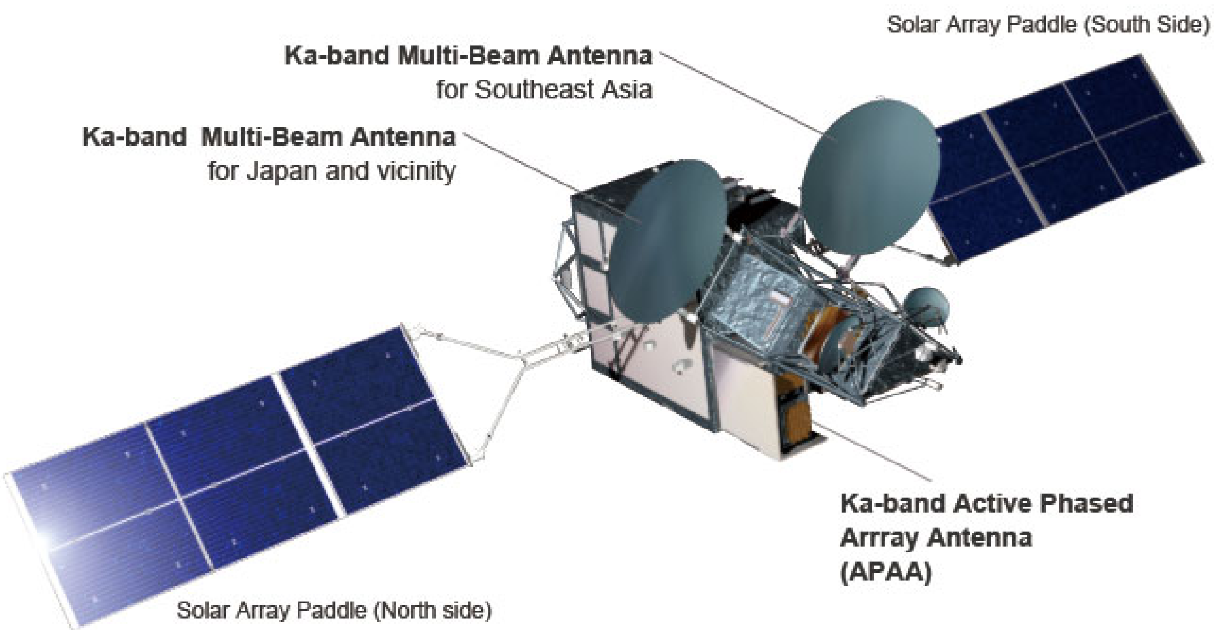

Figure 12. Kizuna Data Satellite. *Kizuna* means "strong bond" in English.[111]

[110] http://www.jaxa.jp/countdown/f14/overview/kizuna_e.html
[111] http://www.jaxa.jp/countdown/f14/overview/kizuna_e.html

VI. Putting It into Practice

We live in a socially interconnected society that is learning to respond collectively rather than individually. As socially and economically empowered populations increase, so does the impulse to respond to crises effectively. In 2011 alone, global government and public spending in crisis event response and recovery will exceed $500 billion.[112] We can therefore address the challenges listed above with governance models and application standards across an interconnected community. There are many ideas, concepts, and innovative technologies on the horizon that will be most effective through cooperation and collaboration. We must start by understanding the life cycle of services and technology and then couple that cycle with the needs of the HA/DR community.

Headquarters – The Operations Center

The operations center is the centralized location for information during an HA/DR event and delegates tasks to the responders on the ground. The center has significant advantages because it has access to advanced data management through high-speed networks that access the Internet, opening access to resources from all parts of the world. This enables reasonably fast response times to challenges and obstacles such as language translation and publishing data file layers to remote repositories. However, the technology available in the affected regions directly affects access to these resources and thus the response results.

Technological shortfalls were clearly evident in Haiti immediately after the 2010 earthquake. U.S. military reachback resources were coordinated at U.S. Southern Command (USSOUTHCOM) in Miami, Florida, and at MacDill Air Force Base in Tampa, Florida. Joint NGO and IO operations were setup on the fly in Port-au-Prince with limited telecommunications and technology access.[113] The demand for imagery on the ground was a priority and consumed significant bandwidth, which impacted other important needs, for example the need to transmit medical and logistics information. APAN at USSOUTHCOM became one of several possible coordination portals.[114] Ushahidi[115] and OSM[116] published real-time map-based situation reports, and data streams also appeared through SMS, Twitter, InSTEDD, the Reuters Emergency Information Service and Project 4636. Through significant volunteer efforts, datasets were then compiled and distributed to user groups, then layered as mapped points of damage to transportation, shelter locations, emergency twitter messages, SMS

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[112] Compile your own economic disaster loss analysis through ED-MAT - http://www.emdat.be/
The Centre for Research on the Epidemiology of Disasters (CRED) was established in 1973 as a non-profit institution, with international status under the Belgian Law. It is located within the School of Public Health of the Université Catholique de Louvain (UCL) in Brussels. CRED became a World health Organisation Collaborating Centre in 1980 and has expanded its support of the WHO Global Programme for Emergency Preparedness and Response. Since then, it has increased its international network substantially. It has collaborative status with the United Nations Department of Humanitarian Affairs (UN-DHA), and also works in collaboration with the European Union Humanitarian Office (ECHO), the International Federation of the Red Cross and Red Crescent, the Office of Foreign Disaster Assistance (OFDA-USAID) as well as with non-governmental agencies such as the International Committee of the Red Cross and Red Croissant (ICRCRC, Switzerland). During the 90s, the Centre actively promoted the International Decade for Natural Disaster Reduction (IDNDR) within its activities.

[113] The ability to leverage crowdsourced information, open source GIS and commercial humanitarian logistics chains to deliver capabilities quickly and inexpensively is being examined in a new initiative by DoD, NATO's Allied Command Transformation (ACT) and the International Transformation (ITX) Chairs Newtwork termed "Quick Wins at Low Cost (QW@LC).

[114] https://community.apan.org/pfa/haiti_HA/DR/ - also "Haiti to Helmand" http://star-tides.net/node/2046 and the ICT For Peace Foundation's "Sifting Hype from Reality" http://ict4peace.org/updates/peacebuilding-in-the-information-age-sifting-hype-from-reality

[115] http://haiti.ushahidi.com/

[116] http://www.openstreetmap.org/index.html?lat=18.89&lon=-72.83&zoom=7

translation and other disaster event conditions. This work was not transcribed across all portals that had updated imagery; multiple compilations of the data were published on different websites. For more information, see U.N.'s Disaster Response 2.0.[117]

Language barriers in data sharing can be addressed at the operations centers with translators, both human and machine-based. Translation from French Creole to English in Haiti was a significant challenge. Language issues are often ignored and demand significant attention and focus. During rescue operations, volunteers translated French Creole to English[118] to submit SMS-based emergency requests that proved very valuable during the search and rescue phase. During the transition to recovery efforts, English updates translated into Creole were sporadic at best. Use of imagery in concert with layered data opportunities must take into account the need to have multiple language support of all reference points on an image. Therefore the images must be made available to a variety of sources ensuring wide transcription and translation opportunities (see figure 21.)

The Field − Forward Operating Headquarters

Mobile data center systems should be considered as a component of future large-scale disaster deployments. They can be made 100 percent self-contained in network services and in power. The forward operating headquarters is where many of the local datasets will be compiled for use in the relief effort. In doing so, size of the datasets is often the most important obstacle to overcome. Currently, the smaller the user device screen is—graphics resolution, etc.—the more partitioned image tiles will be required to transport as data files between the edge host and the device as a user scrolls from one grid to the next. Logistics, tasking orders and search and rescue teams continually face technical and time limitations on how to best leverage imagery. A team in region A usually does not need imagery for any other area. There are no broadly published guidelines for addressing such policies and needs assessments. See figure 25 for example of KML information layer overload.

Reach Back

Some subscribers to the imagery will have no need to interact with the local communities in real-time and will therefore work from their base as reach back operations. These groups include international aid agencies, foreign government assistance agencies, and volunteer groups. Many of these groups will work from home and from their offices, connected to broadband Internet networks, and therefore do not have the bandwidth issues of those on the ground. The reach back community often automates many of the datasets that are compiled for use in HA/DR responses and composition of this data often happens thousands of miles away from the disaster.

For reach back to be effective and capable of transmitting imagery forward combined with data layers, field communications elements require next generation communications technology improvements. Alcatel-Lucent's Bell Labs have designed Base Mobile Radio technology as an example that is cost effective, sustainable in an HA/DR environment and consumes very little power. See figures 3 through 5 illustrating process flows in appendix A.

[117] http://www.globalproblems-globalsolutions-files.org/gpgs_files/pdf/2011/DisasterResponse.pdf
[118] http://www.globalproblems-globalsolutions-files.org/gpgs_files/pdf/2011/DisasterResponse.pdf page 11

VII. Recommendations

Not all suggestions listed below are applicable to every type of disaster that occurs. There are, however, themes in cartography and imagery technology that have been seen repeatedly.

Resources

Existing imagery policies, laws and processes need work. Government agencies and service providers need to come to an agreement on where and how the source imagery should be freely available to the HA/DR community, using standards that are accepted worldwide *and* are useable in popular (exportable) formats. Although this principle is recognized, it is not law in any region of the world known to the author.

No matter how easy it is to use, technology still has its limitations in the field. People save lives, technology does not, and technology is not the point—effective help is the point. Technology is merely a tool to accomplish a task. While often indispensible, it is—like training, policy and law—a means to a useful end.

Used efficiently and with transparency, imagery and digital map technology are a valuable set of tools that can be marshaled for improved productivity, public safety and stability in a disaster zone. Technical solutions must be managed in parallel with the needs of a population under stress, keeping in mind the local language, culture and customs. These last two issues are not directly addressed in the recommendations herein but are recognized as necessary.

Data Sharing

Military organizations own some of the very best imagery. However, there are often legal constraints for sharing outside of military alliances. While those barriers are dropping as law and policy are amended, the culture is still often adversarial and that issue needs work. One of the best methods for improving relationships for data sharing is the embedding of staff from each side within the other. Civil-Military exchange opportunities can be particularly effective when focused through information and communication technology (ICT). The Civil-Military Centre of Excellence (CCOE) in Enschede, Netherlands, is exploring ways to improve these kinds of cooperation.

As users of maps and imagery, military organizations also are learning new techniques to use this data in collaborative efforts with civilian volunteer technical communities. In Haiti, USSOUTHCOM found imagery, digital open source maps and websites that hosted them (such as Ushahidi and OpenStreetMap) to occasionally be of greater value than their own assets.[119] In Haiti, unsecured sources such as Twitter, Facebook, Wikipedia, and SMS text messages were useful, but the feeds were not, as far as has been reported, integrated into any military mapping system, application or device attached to the military data network. The PEAK (Pre-Positioned Expeditionary Assistance Kits) JCTD (Joint Capability Technology Demonstration), developed by the U.S. military in 2010-2011, has a pico-cell communications system to plug into local communication systems to leverage local situational awareness.

Federal development agencies (such as the U.S. Agency for International Development) should consider aerial and satellite imagery an early component of aid supplied during a crisis. The imagery supplied should also be made publicly available to the host nation, the United Nations, NGOs and volunteer organizations that are supporting the disaster response. The benefits would be substantial in cost reduction and organizational effectiveness.

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[119] Author support of United States Marine Corps - 24th Marine Expeditionary Unit: Haiti – February 2010.
Author support of United States Army - 2nd Battalion: 82nd Airborne: Haiti – January 2010

The United Nations hosts a Web portal under the United Nations Office for Outer Space Affairs where it has a collection of resources. The site lists trusted datasets including emergency mapping datasets in pre and post disaster files. The formats include KML and KMZ mapping files, JPG and PNG graphics formats, and more. The site includes metadata for the publisher, date and other ancillary information about the data. This allows any user to pick and choose what information is relevant to the user's specific needs. This collection of data has been compiled as a result of lessons from prior emergencies.[120]

Governments should be prepared to host and store new imagery on government-supplied and operated Internet networks with storage freely available to the humanitarian community for the duration of response and relief efforts where U.S. dollars are involved (some of which is provided for in DODI 8220.02.) The financial benefit from the efficiencies achieved by good maps far outweighs the marginal cost of a little temporary storage. The methods, templates and designs established by the Visualization Center at San Diego State University can serve as a useful model. Another option is for government agencies to allow free export of imagery files to commercial network suppliers with the provision that all files thus supplied are to be considered free and open source, issued under Creative Commons license. [121]

Software Applications

Today a substantial investment in cartographic products is being made by volunteer, non-profit, and corporate entities, but much utility is at risk if the applications can't talk to each other. APIs, the bridges between applications, should be streamlined and exportable to more than one end user service provider. Software applications should be designed to operate in a distributed architecture framework. Web site platform applications such as the Sahana Disaster Management program [122] and Ushahidi are good examples of this, and are being recognized by governments as powerful tools for humanitarian response.[123]

Structured standards for dataset inputs *and* outputs could be considered one next step in volunteer and public response user groups. The broad use of KML, XML, X-HTML and many other formats not yet developed requires a discussion about global interoperability. A governance structure of policies and "how to" guidelines might be valuable.

Data Layer Source Publishing

A structure for retrieving information is also needed. There are thousands of volunteer code writers creating KML, XML and other third-party extensions containing valuable visualization datasets that are not being used to their maximum effect. Google's volunteer bulletin board for KML files contained a wealth of information and is not optimized to its full potential. The structure of how the data is placed, who wrote the code, what is inside each file and how it's published are all areas that could be addressed. Several files are full of accurate and detailed information surrounding a crisis or event, but lack metadata for context. Only through a multi-layered Web search is the information about this file likely to be found, requiring substantial and carefully-aimed effort.[124]

Google supports sites such as http://bbs.keyhole.com, which hosts vast amounts of information for the HA/DR community, though it is not well known in the response community. If a new user had to use the

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[120] http://www.un-spider.org/japan-pacific
[121] http://creativecommons.org/
[122] http://www.sahanafoundation.org/
[123] http://www.crisismappers.net/forum/topics/eqorgnz-about-the-project
[124] http://bbs.keyhole.com

bulletin board front page as a starting point, the probability of finding HA/DR-related information for an event is not likely.

Google does publish crisis response web pages when a disaster strikes and has done so consistently over the last several years. Google's Japan disaster response page is an excellent example of how KML resources are made available, but it does not link back to the Keyhole Bulletin Board Service (BBS) site. This is likely because the community that supports and uses the Keyhole BBS site is not solely directed at supporting disasters, but at all forums of KML users.[125] HA/DR specialists do not have the time to go through thousands of results from a search on Keyhole BBS. This is not the fault of the administrators of the site; it is a volunteer community that has no formal governance. However, a methodology to extract the valuable resources that this site offers needs to be encouraged and explored.

Application Data – Priority Request for Comment (RFC) Standards

If data streams are going to be used to assist in an HA/DR response, they should be delivered with an exceptional level of trust and relevance, and be sent with high priority. Specialized reference metadata standards could be published and approved by several governance bodies including the International Telecommunications Union and the Internet Society. Examples include hashtags (#hashtag) used on Twitter and other applications. #Hashtag usage is currently flooding HA/DR websites, often (based on a quick personal survey) with less-than-helpful information. The popularity and use of #hashtags was spearheaded by its adoption by many during the Web 2.0 era and has been further enhanced by companies specializing in Search Engine Optimization (SEO). Web 2.0 (or its follow-on Web 3.0) and SEO are not sanctioned bodies; they are historical terms of reference to standards and capabilities that websites adopt for collaborative and shared environments. For example, a website that offers XML services, such as RSS, is a site that complies with Web 2.0 guidelines.[126]

It is recommended that clearly defined and restricted use of specialized #hashtags be implemented using a common crisis taxonomy. For example:

#country + location + emergency code + supplemental data

The above example, if located in Washington, DC, U.S.A., would be published as:

#USAWashingtonDC911Trapped

The specialized use of #hashtags could be implemented in the same cultural manner as 911, 999, and other emergency phone number systems. Metadata using these tags would also be given priority when sent over the Internet through communication networks (landline, broadband Internet or mobile text or data). Abuse of ratified emergency #hashtags would be a prosecutable offense. Implementing such as system could reduce the amount of data that crisis mappers and other response organizations need to monitor and improve the quality of data to be filtered. Other forms of #Hashtags syllabus can also be implemented such as:

#country + location + information code (411) + supplemental data

#country + location + water (H20) + supplemental data

#country + location + Fire (FD) + supplemental data

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[125] http://www.google.com/crisisresponse/japanquake2011.html
[126] http://www.w3.org/tr/wcag

These meta-tags could be harnessed and structured in a manner that can be further labeled in communication networks for enhanced Type of Service (ToS) or Quality of Service (QoS) priority transmission. Perhaps we could recommend that a Request for Comment (RFC) be published for review by the IETF, which is managed by the Internet Society.

Devices

Small form factor devices offer new opportunities to use imagery as key information foundations for most HA/DR scenarios. Costs for them continue to drop. Software to operate on these devices has become more flexible for application development, particularly open source operating systems like Android.

Two significant issues need to be addressed with respect to new device implementation: training and distribution logistics.

- Training: Consumers have essentially unlimited time to learn new devices. If, however, a device is complex enough to require technical manuals and formal support, the value of the package to humanitarian responders might be significantly reduced.
- Distribution logistics: Managers realize that devices may cost only $1.00 initially, but when training, IT processing and distribution are added, the deployed costs can multiply by a factor of four or more, not including network access. As in any large organization, the logistics associated with change impede capability enhancement.

Communications

Wireless and satellite network link technology continue to improve along the same curve as hardware. The need for large form factors such as full size desktop computers or even laptops is disappearing. Long-range network access and mobile cell towers are becoming smaller each year, sometimes with their own off-grid power. Emergency repair services and infrastructure augmentation capabilities have improved significantly over the past 10 years. Network access costs during crises are now being reviewed by large telecommunication providers and, in some cases, costs will be waived for the duration of the event.

Transmission technology is rapidly changing as well. Cellular tower size and footprint requirements are shrinking dramatically. Bell Labs recently revealed their “LightRadio,” (using "Base Station on a Chip" technology) with high functionality, light weight, and very low power consumption. This design will improve availability to broadband network solutions in areas where traditional mobile phone access has proven difficult.

Radio processing has been reduced in size by a factor of 1,000. Similar to new semiconductor architectures such as System on Chip/Programmable Systems on Chip,[127] Alcatel claims the cost of owning and operating mobile transmission services are reduced by half. The system can take advantage of green energy sources and backhaul network trunking on the same devices. To increase capacity, range, and bandwidth requirements, all the mobile operator will need to do is stack more cubes and will not be required to add additional radio processing electronics or antenna needs.

[127] http://en.wikipedia.org/wiki/PSoC

Alcatel-Lucent has partnered with Hewlett Packard and Freescale Semiconductor to build the mobile base station product for its software and hardware requirements. The consortium has signed a 10-year collaboration agreement.[128]

Communications Regulations

The above described technology is a few years away from wide spread deployment. The future shows promise for HA/DR field operations needing high-speed connectivity to the Internet. This is not a universal capability and must be considered where imagery service needs exist. Current network access services vary around the world and must be taken into account before deploying advanced devices and expecting equal results regardless of where the disaster has taken place. While it is standard policy for teams to have pencil and paper on the ground, technology services, particularly communications, are globally improving and becoming reliable for crisis deployments.

Governments today do not require telecommunication providers to have redundant mobile networks or standby requirements such as Cell on Wheels (COW) equipment. Most governments have relied upon their military institutions to provide backup needs or to assist in repairs. As the scale of a disaster increases, internal resources are unlikely to prove sufficient. In some cases the governments have refused international IT support or have imposed severe regulatory barriers or time-consuming emergency permits and tariffs that make effective and timely interventions impossible.[129]

Communications –RFC Standards

It is recommended that a series of new emergency use application and data payloads be created. Some of this work is now underway, following the Internet Engineering Steering Group[130] process, managed by the IETF.[131] Accomplished through the RFC peer and team expert review steps, such RFCs become standards with which hardware and software developer vendors can comply. Some of the following recommendations are in the process of being reviewed, while others have not yet been successful.

Quality of Service (QoS) and Type of Service (ToS) RFCs for Emergency Use

Voice and network communication services used in HA/DR operations should have telecom priority standards developed for use. These include the ability to create priority queues for critical datasets, mobile text and I.P. data from smart phone and tablet devices. Similar to QoS and ToS RFCs, none explicitly exist today for emergency use of important data transmission. This is an important issue where imagery and layered meta-data are concerned. These files are a significant transport network point of congestion, not only at the event location but, also across every network access point, from the data center that hosts imagery to metadata that is sourced from multiple locations attempting to be retrieved by HA/DR teams.

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[128] http://www.youtube.com/watch?v=7de2e-pUc9c

[129] Hurricane Katrina – Ericsson offers complete cellular network for deployment
http://www.ericsson.com/ericsson/news/archive/2005/050909_er.shtml
http://www.nytimes.com/2005/09/07/world/americas/07iht-relief.html?_r=1
http://en.wikipedia.org/wiki/Swedish_response_to_Hurricane_Katrina
Earthquake Haiti – Author's direct notification of Network Equipment Import tariffs prevented donated equipment to be shipped. Author with the help of Motorola Canada found a complete public safety radio system recently decommissioned just before the earthquake hit, sitting on pallets ready to be shipped. It was 6 months before the notification was sent to the author and beyond the financial capacity of any organization.

[130] http://www.ietf.org/iesg/

[131] http://www.ietf.org/

Communications – Government Regulations

Government communications regulators need to consider regulations that account for disaster recovery. Communications regulators should consider specific requirements such as having COW service be a mandatory requirement in order to operate wireless commercial services that are stored at locations deemed safe from a foreseeable hazard.

Social Networks

Visualization of conditions at any HA/DR event quickly establishes facts, situational awareness, dynamic conditions and courses of action that need to be taken. Imagery eliminates ambiguity in many situations and environments and acts as a language translation between different cultures. No longer is it a question of who has access, but how fast it can be deployed.

The HA/DR community might also begin developing educational programs on how ordinary people can use applications such as Twitter and other social media for disaster response support. Examples include language translation on layered images and maps.

CrisisMappers.net, mentioned earlier, is a group of more than 4,500 volunteers that have been brought together by Patrick Meier[132] and Jen Ziemke.[133] It is the core of collaboration efforts that can be deployed anywhere in the world. CrisisMappers has established workshops and steering committees to set guidelines and standardize functions and capabilities for sites that deliver imagery and layered datasets. This group, which today consists of diverse and talented volunteers from all walks of life, might soon evolve into a professional volunteer organization of trusted capabilities and skill sets and they are worth watching.

STAR−TIDES is an example of an organization capturing ideas, solutions, and concepts across a range of disaster response domains and sharing them freely with anyone interested.[134] It is located at the National Defense University in Washington, DC, and the acronym stands for "Sharing To Accelerate Research, Transformative Innovation for Development and Emergency Support."

Military

As described throughout this document, the military has played a key role in every catastrophic disaster in the past 50 years in all region of the world. Many of them have contributed to the publication of imagery and the use of open source tools. In the past, militaries have been confined in narrow and very specific duties and operational roles. Today they often provide the backbone and the front end for many of the needs during a disaster. In addition to its traditional HA/DR functions as described in the Government-imagery supplier role, some militaries have the capability to assist in the processing and delivery of post-event imagery and to comply with industry cartography and mapping standards.

If a foreign military institution has similar guidance, it might take into consideration the sharing and distribution of imagery and associated GIS metadata. Imagery and its metadata could be made available to the HA/DR community while still meeting international and host-nation mandates for sovereignty and security.

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[132] http://irevolution.net/bio/
[133] http://www.jenziemke.net/
[134] http://star-tides.net/ - Disclosure: The author has collaborated and advised on several HA/DR subject areas with this organization.

This policy is similar to the DOD with respect to humanitarian support such as DOD Instruction 2105.02[135] (Humanitarian and Civic Assistance, Dec. 2, 2008) and DoD Instruction 8220.02.[136]

An example of these processes in action occurred in Jalalabad, Afghanistan, documented by Dr. Dave Warner of MindTel. It required the cooperation of several U.S. Government agencies and the U.S. Military, and is documented in the reference.[137]

In brief, in 2006 and 2007, the U.S. Naval Research Laboratory and USGS implemented a map server to support imagery services required for Project *Rampant Lion*, an unclassified aerial survey of Afghanistan. Rampant Lion consumed more than 20 terabytes of data[138] and required more than 40 flights exceeding 220 flight hours using a U.S. Navy NP−3D Orion. In total, Rampant Lion photographed 330,000 square kilometers of the country on more than 65,000 separate images.[139]

Other military air force units around the world have aerial imagery capabilities and could be made available for use in emergencies. For several years the U.S. Air Force, Navy and Coast Guard have supplied the bulk of government supplied aerial imagery when tasked, but they need not carry this burden alone. Countries that have this capability and have been involved in recent disasters but either did not offer or supply or receive imagery service requests include Australia, Canada, China, France, Germany, Japan, New Zealand, Russia, Sweden and the United Kingdom.

Understanding Cultural Interpretation: Data as Symbols

We tend to forget the multi-cultural demands of our world. While technology evolves, all HA/DR participants need to recognize the continued requirement for learning cultural and social differences in each country. Streams of data when placed on a map act as symbols. In many cultures symbols are integral to effective communication. Developers and software programmers who design APIs might benefit from considering the communication resources within societies at risk.

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135 http://www.dtic.mil/whs/directives/corres/pdf/220502p.pdf

136 http://www.dtic.mil/whs/directives/corres/pdf/822002p.pdf

137 http://www.oss.net/dynamaster/file_archive/100710/8e33760a723ce3c75d733058441d1645/Cyber%20Pass%20Meets%20Khyber%20Pass.pdf– see also http://mapserver.cmf.nrl.navy.mil/

138 http://www.nrl.navy.mil/media/news-releases/2010/aerogeophysical-survey-provides-promising-prospects-of-economic-development-in-afghanistan
The amount of storage required for Project Rampant Lion was significantly less than what is used today for high resolution disaster imagery from aerial flights and Satellite passes for Haiti 2010 or Japan 2011. See specifications of Afghanistan missions as noted on pages 108 and 109 of the report.

139 http://mapserver.cmf.nrl.navy.mil/FA7rev.pdf - Page 108
65,000 high-resolution photogrammetric Images were collected.
Other Systems used included:
L-Band Polarimetric Imaging Radar,
Magnetometer,
Gravity Meter,
Photogrammetric Camera,
Hyperspecteral Camera,
Synthetic Aperture Camera,
Applanix DSS Camera

Appendix A. Imagery, Maps, and Usage

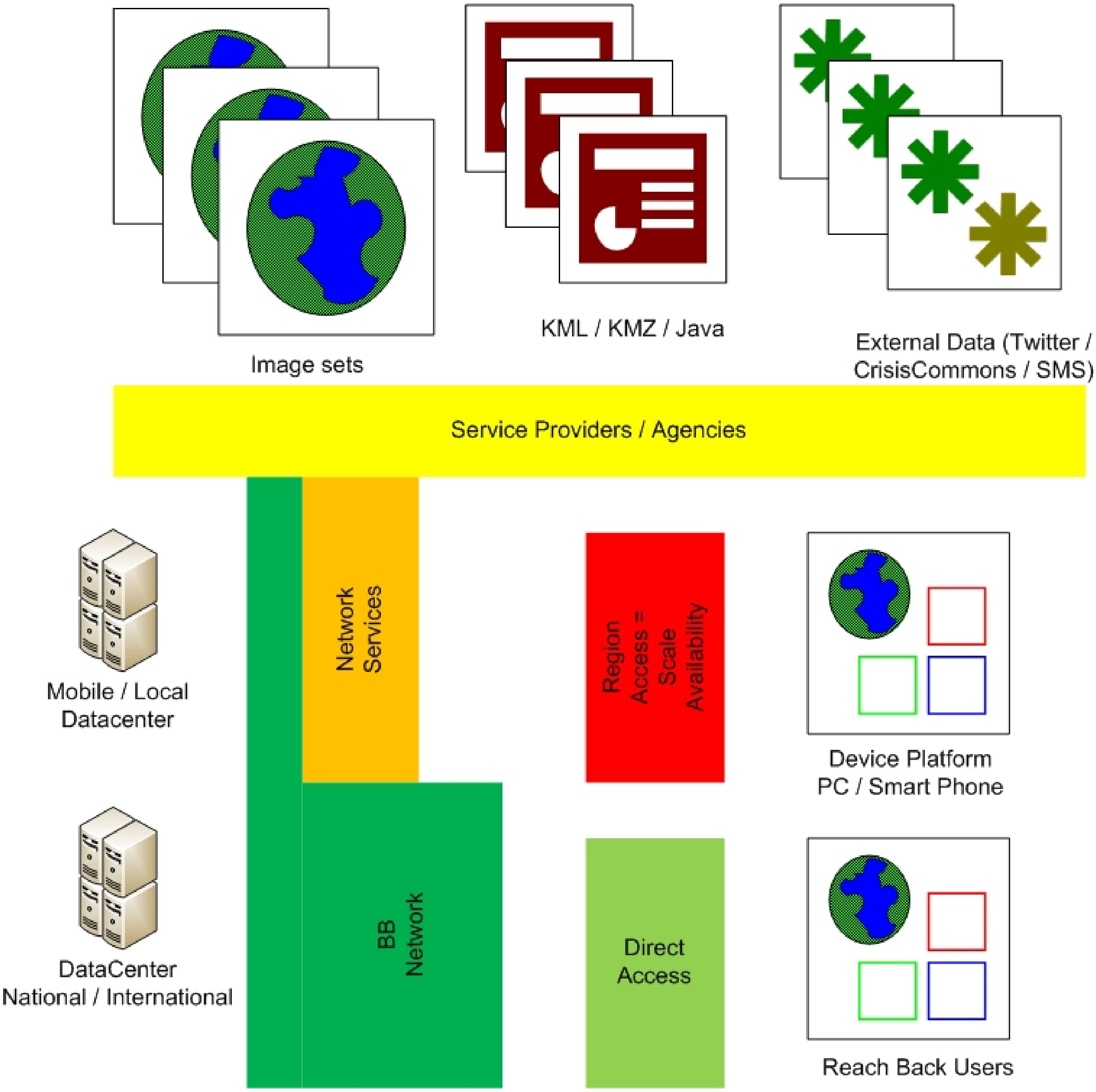

Figure 13. Image server to user

This diagram illustrates the different shared resources used in collaboration to export valuable information to a user group. Not all groups share or use the same resources to create a finished product. The weakest link is reaching the device platforms (smartphones, tablets) used in the field due to the limited bandwidth that may be available. Each process is completed in sequentially: Imagery → layered datasets → provider → host service → network infrastructure → user [140]

[140] Rapid Response Consulting, Toronto, Ontario

Imagery Processing and Utilization

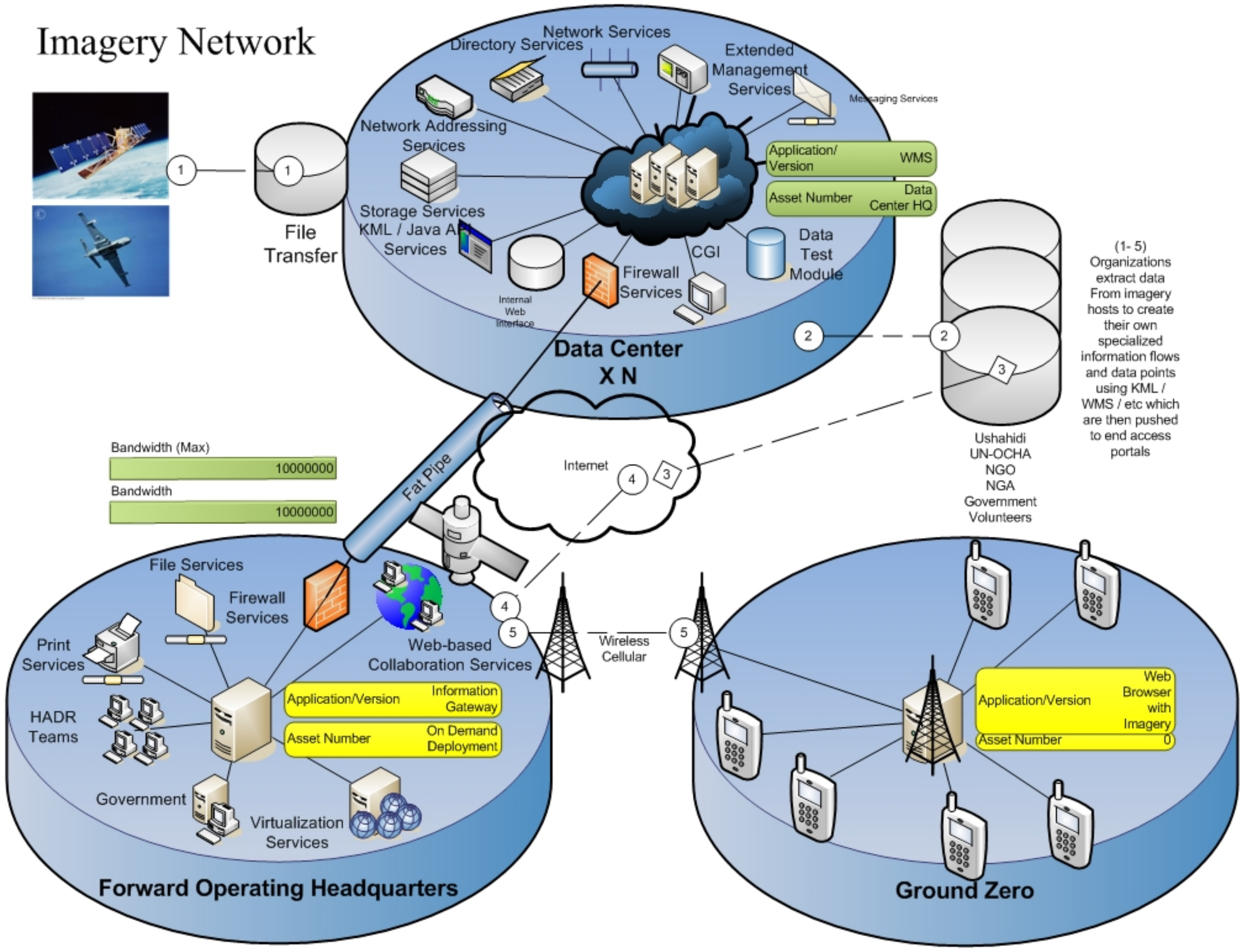

Figure 14. Imagery Network[141]

The end user retrieves imagery and data from sources simultaneously, and not in serial fashion, as shown above. The data linkage (programming) is serial, but the transmission is not. Several reprocessing steps may occur (translation) and not all devices may recognize the datasets being fed into the user's device browser or third-party application. Language translation can crash a user's device or create significant delays in the transmission of data. The data center is the core; forward operating headquarters is the edge, while ground zero represents the user community. The data center formula "X N" represents the data center collection location "X" (satellite ground station or aircraft landing site location) of the imagery multiplied by "N"—the various locations where the imagery is collected and then distributed. Data centers are available all over the world. Google's image sets are housed in a variety of international data centers, as are Microsoft's Virtual Earth/Bing. Forward operating headquarters are often housed in a safe location close to the disaster site that can vary from a few kilometers to hundreds. The user groups in the Internet Connection Sharing hot zone ("Ground Zero") will use a variety of communications networks including wireless, satellite, and terrestrial landline networks if operational, each with potential bandwidth limitations. Not all events have forward operating headquarters.

[141] Rapid Response Consulting, Toronto, Ontario

Application Architecture–KML

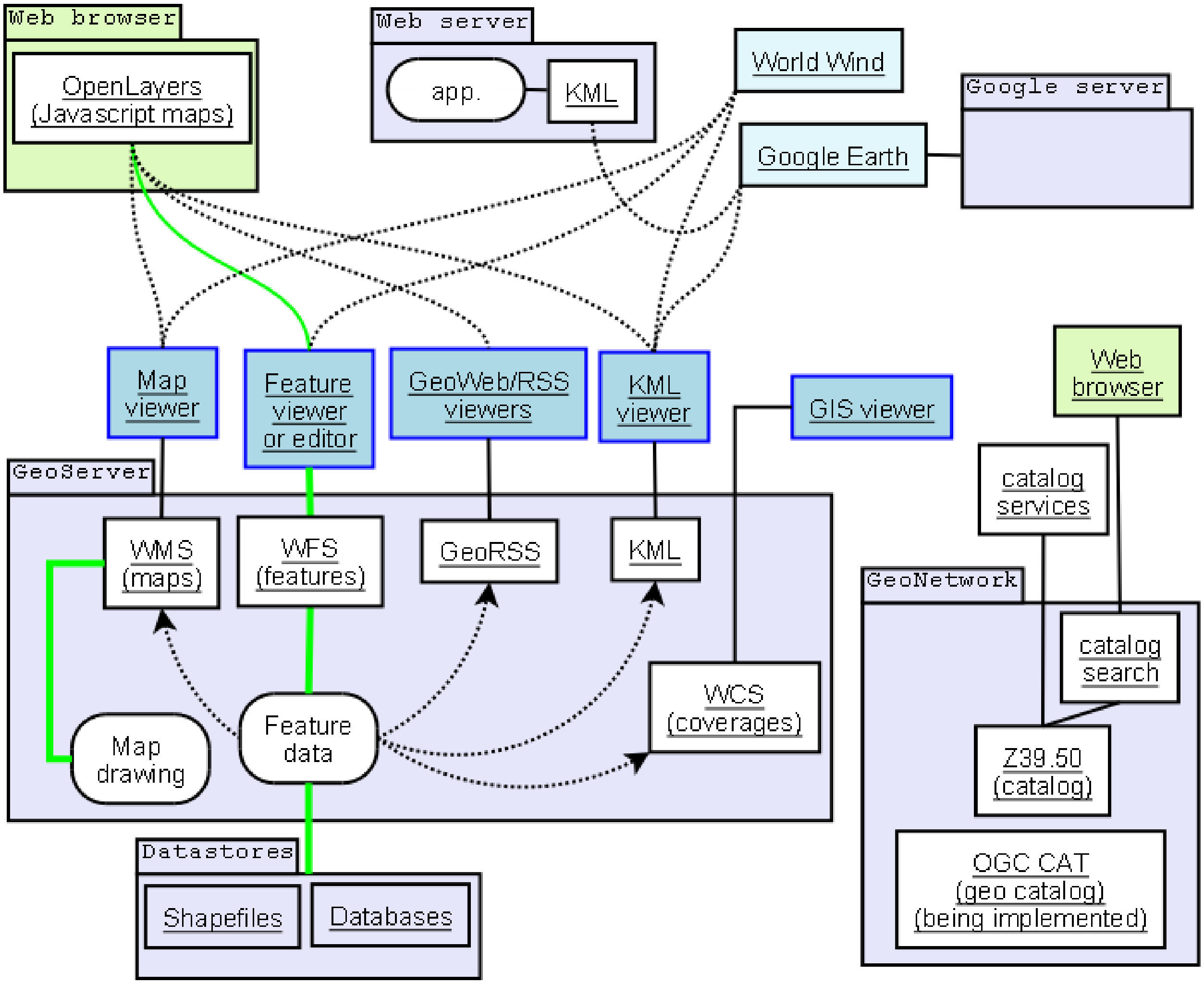

Figure 15. Software Architecture of how KML is Used

A sample architecture for KML, this configuration is only one approach for collection and compiling raw data into meaningful data sets to layer on top of cartography and digital imagery maps. The design of XML, X-HTML, and others often follow similar processing flows but are not invariant. It's important to recognize that developers of these solutions may or may not adhere to a specific user group's needs. Since many of these applications are designed by volunteer groups for use in the field, there is no cohesive team that collaborates to ensure minimum requirements and outputs are followed. This potentially creates confusion in the field where the information is critical and must be accurate to be of any use. Other versions of code used for data layering include JSON[142] and X-HTML.

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[142] http://www.json.org/

Ushahidi Volunteer Data Flow

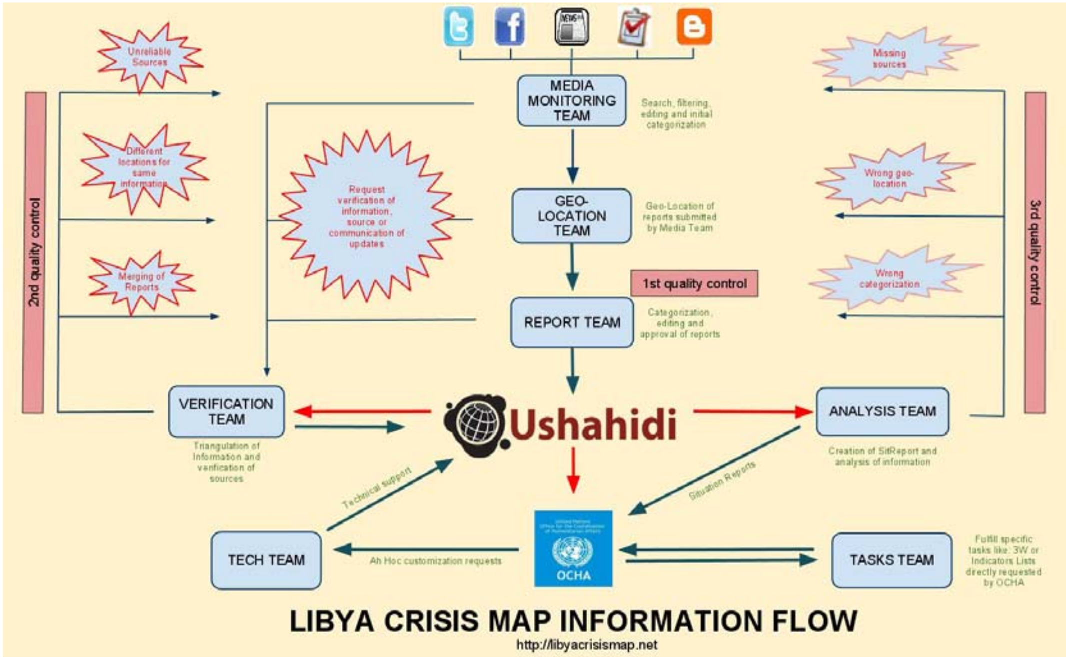

Figure 16. The use of the Ushahidi platform by the Standby Task Force[143], as structured for use for Libya crowdsourcing information[144]

Ushahidi's platform success stems from its use by organized volunteers, each with skill sets that extract data from multiple sources for publication. These streams of data are often in different formats, protocols, and languages. The teams are organized to maximize their capabilities, and are often nowhere near the event's epicenter. Volunteer programmers, developers, and team coordinators are based all over the world. Once dataflow structures are put into place, they are often then allowed to operate in an automated mode. As illustrated here, they can inject supervisor roles and responsibilities ensuring a level of quality control and verification as required. Depending on the scenario, volunteers could be put into roles that are often considered government roles and responsibilities. To date, dialogues between volunteers and observers who interpret the data have not seen conflicts in this area. This diagram suggests "management" protocols by UN-OCHA.

The term "volunteer" requires clarification. Ushahidi developers are often not the operators of the websites used for humanitarian efforts. The Ushahidi team considers itself a non-profit organization, which implies neutrality. Many of the volunteer teams that compile the data are employees of non-profit organizations or funded by grants from various institutions. The datasets collected from sources as illustrated are freely available for anyone to structure and publish. The type of civil crisis or disaster will sometimes influence how many volunteers (who are truly volunteers with no remuneration, funding, or furnished compensation for their work) and teams are assisting in the response.

Some staffing of the deployed services use resources that are individuals and groups funded by foundations such as the Harvard Humanitarian Initiative, universities, charities, and other foundations.

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143 Standby Task Force: http://blog.standbytaskforce.com
144 Used with permission – Ushahidi

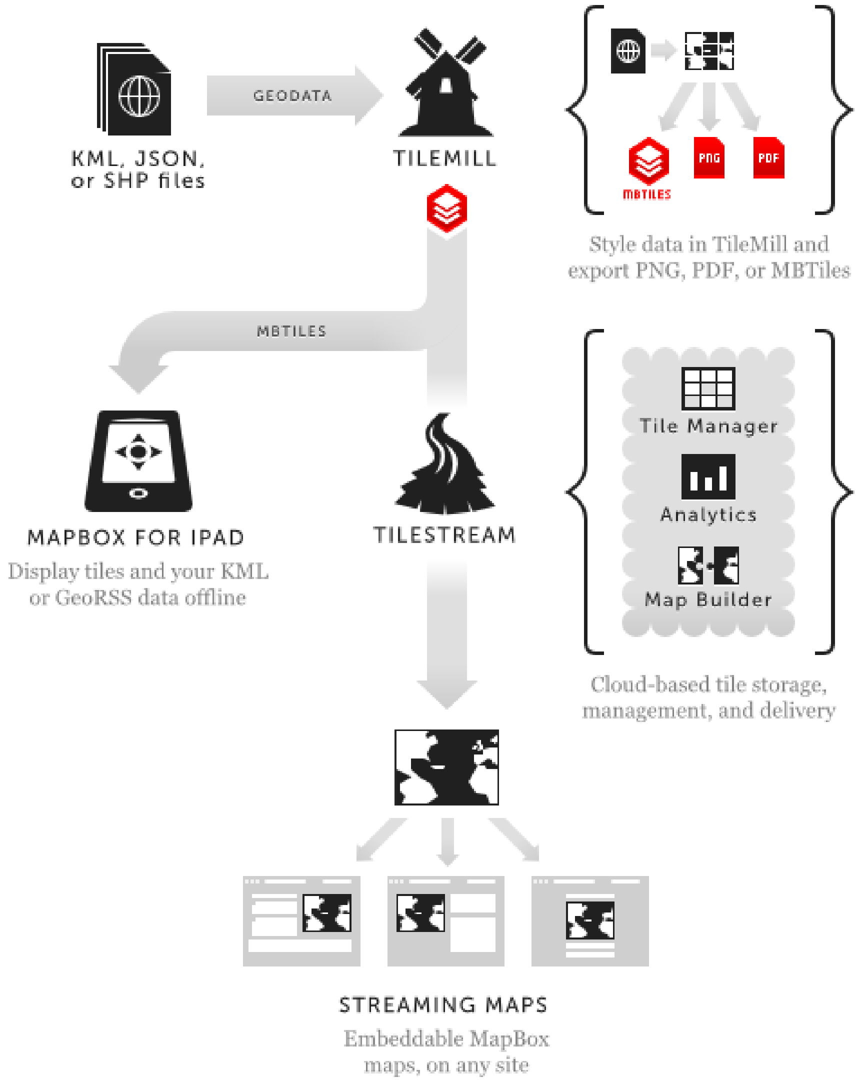

Figure 17. MapBox Architecture[145]

MapBox offers map developers or individual users the ability to create their own maps and pull in metadata feeds from a variety of sources, including popular APIs such as Google Maps API, and OpenLayers. It's compliant with all Hyper Text Markup Language (HTML) standards including HTML 5 and X-HTML. The service supports JavaScript, GeoJSON, GeoTIFF, but not Flash. A significant feature is the ability to view customized maps after downloading them once. Once downloaded, low bandwidth demand data feeds such as RSS can be layered, offering efficient use of available network access.[146] It offers flexibility of allowing a user to download a publisher's finished map and simultaneously allowing users to pull in their own KML files. Current versions of MapBox support some versions of Android and Apple iTunes connected devices such as the iPad.

[145] Used with permission © Mapbox 2011.
[146] Email / Skype Interview with Dave Cole & Will White of MapBox – April 28, 2011.

Appendix B. Humanitarian Assistance / Disaster Relief (HA/DR) Events and Mapping Examples: Lessons Learned

The illustrations in this appendix show examples not only of increasingly sophisticated uses of imagery, but also of ways that it could have been used better and lessons for future contingencies.

New Orleans, Louisiana, Hurricane Katrina 2005

Google Earth, Mapping Critical Infrastructure Damage

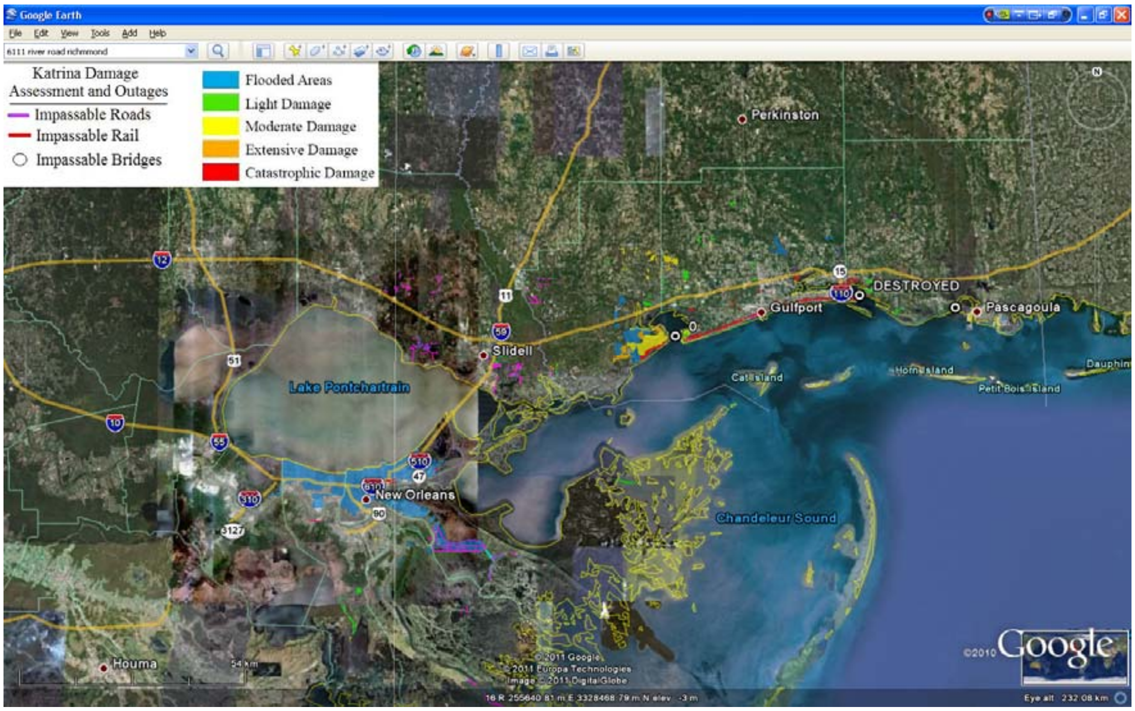

Figure 18. Early Uses of KML and Google Earth: Hurricane Katrina Damage Assessment, September 5, 2005

This map shows the critical infrastructure damage after the Category 3 Hurricane Katrina made landfall on August 29, 2005, wreaking havoc across three states. It represents an early attempt by Google Earth to show the value of KML. The damage polygons are overlaying Google Earth's embedded pre-event imagery, the only imagery readily available. Note the structure of the legend table in the top left of the KML file, a sensible use of icons and colors.[147] Because Google Earth was not ubiquitous in 2005, Google also made a graphic .jpg version available for the public to view without requiring a user to install Google Earth.[148] This is shown in Figure 19, focused on the red, yellow, and blue areas near the center of the image above.

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[147] http://earth.google.com/gallery/kmz/Katrina-damage-outages-05Sep.kmz
[148] http://earth.google.com/images/outages.jpg

Early Efforts at Making Google Earth and KML Maps Available

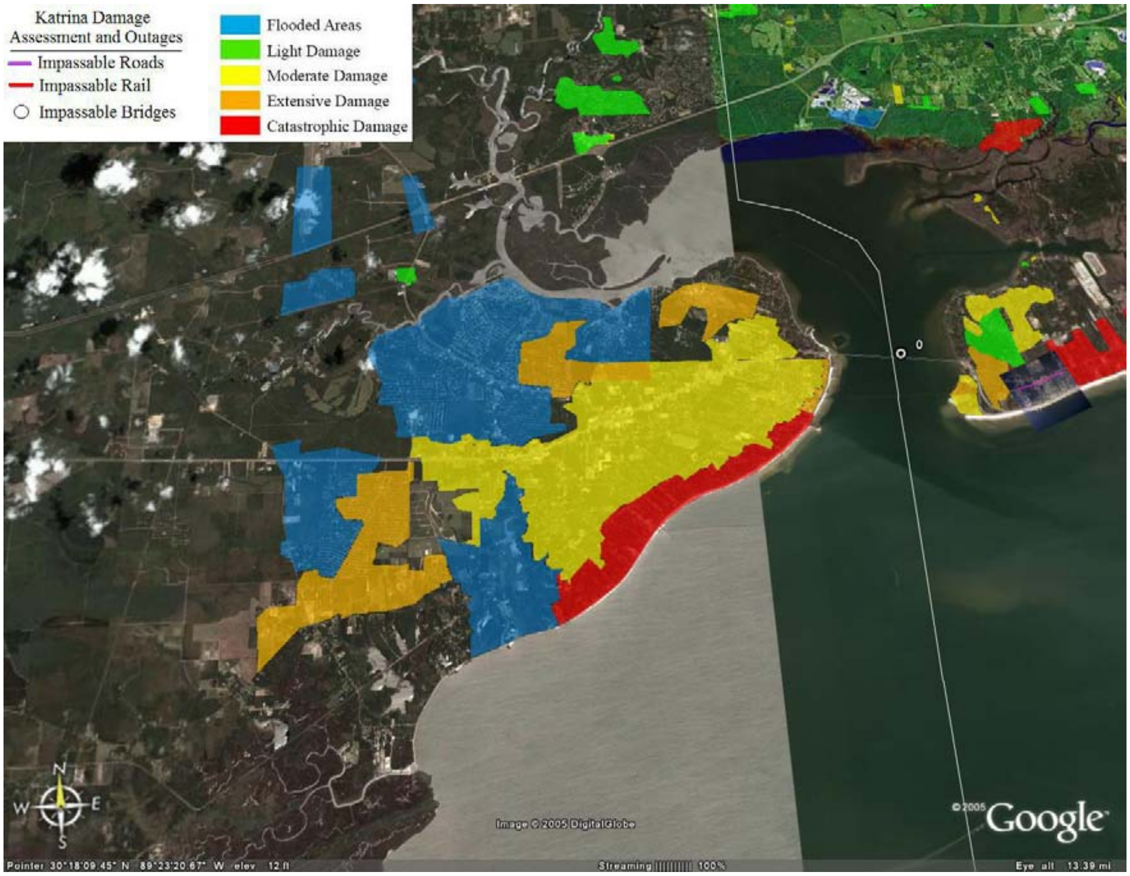

Figure 19. JPG version excerpted from the static map in figure 18, created to make the information available for those who had not installed Google Earth

This is a blow-up of the central part of Figure 18. Notice how the detail of road damage has disappeared in this jpg version.

Early Mapping of Post-event Imagery

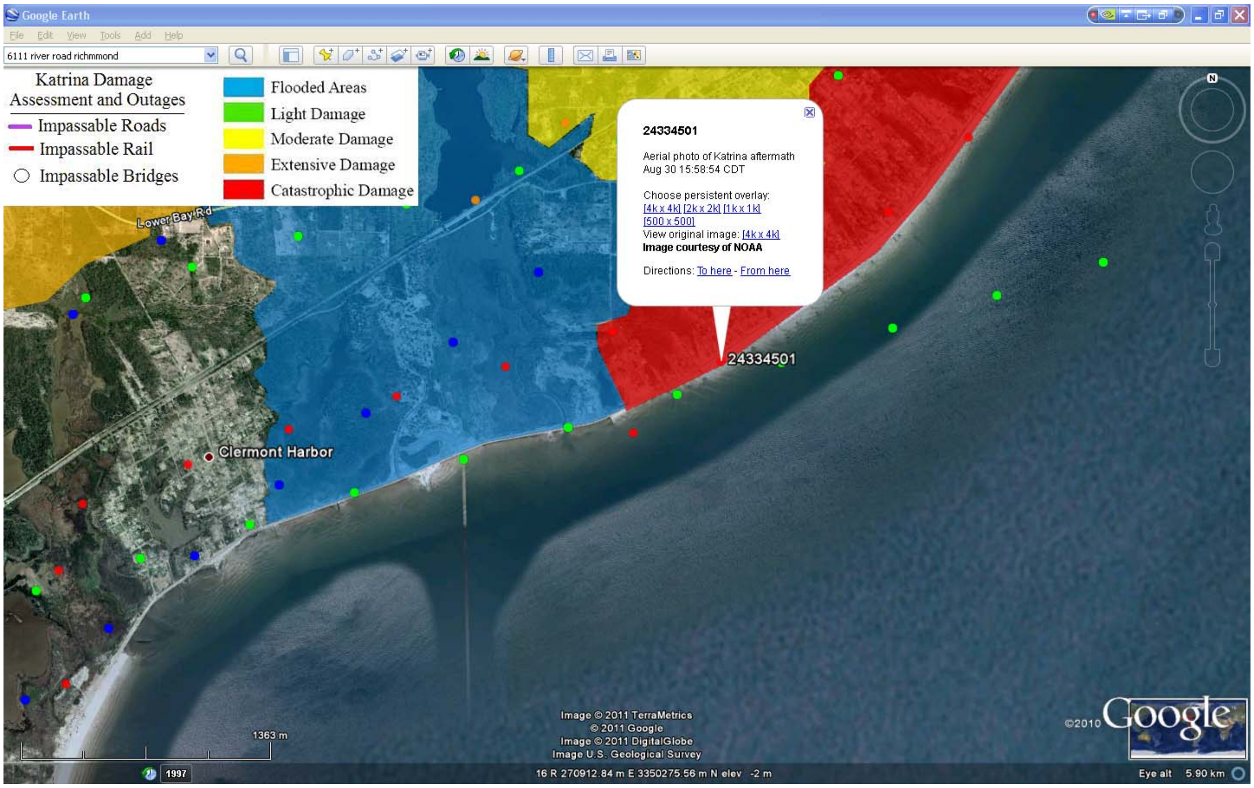

Figure 20. Hurricane Katrina August 30, 2005

This map illustrates an early attempt to map post-event imagery using a point KML file showing damaged locations without downloading an entire set to the user.[149] Dots (shown here in green and red) were clickable, bringing up a bubble describing what the image contained and supplemental data such as date and image size. This technique is valuable from several perspectives: small KML file size, giving a user the flexibility to zoom into a region of interest and then click on various dots and choose which images to download. Lesson Learned: When the user downloaded the image, the KML supplier at this point did not provide reference points to street names or grid coordinates with the image which made it of little value for many organizations such as NGOs, search and rescue, and other agencies. A sample image without any metadata supplied is shown in figure 1.

[149] http://earth.google.com/katrina.html

Port-au-Prince, Haiti, Earthquake 2010

Imagery Missing GPS Coordinates

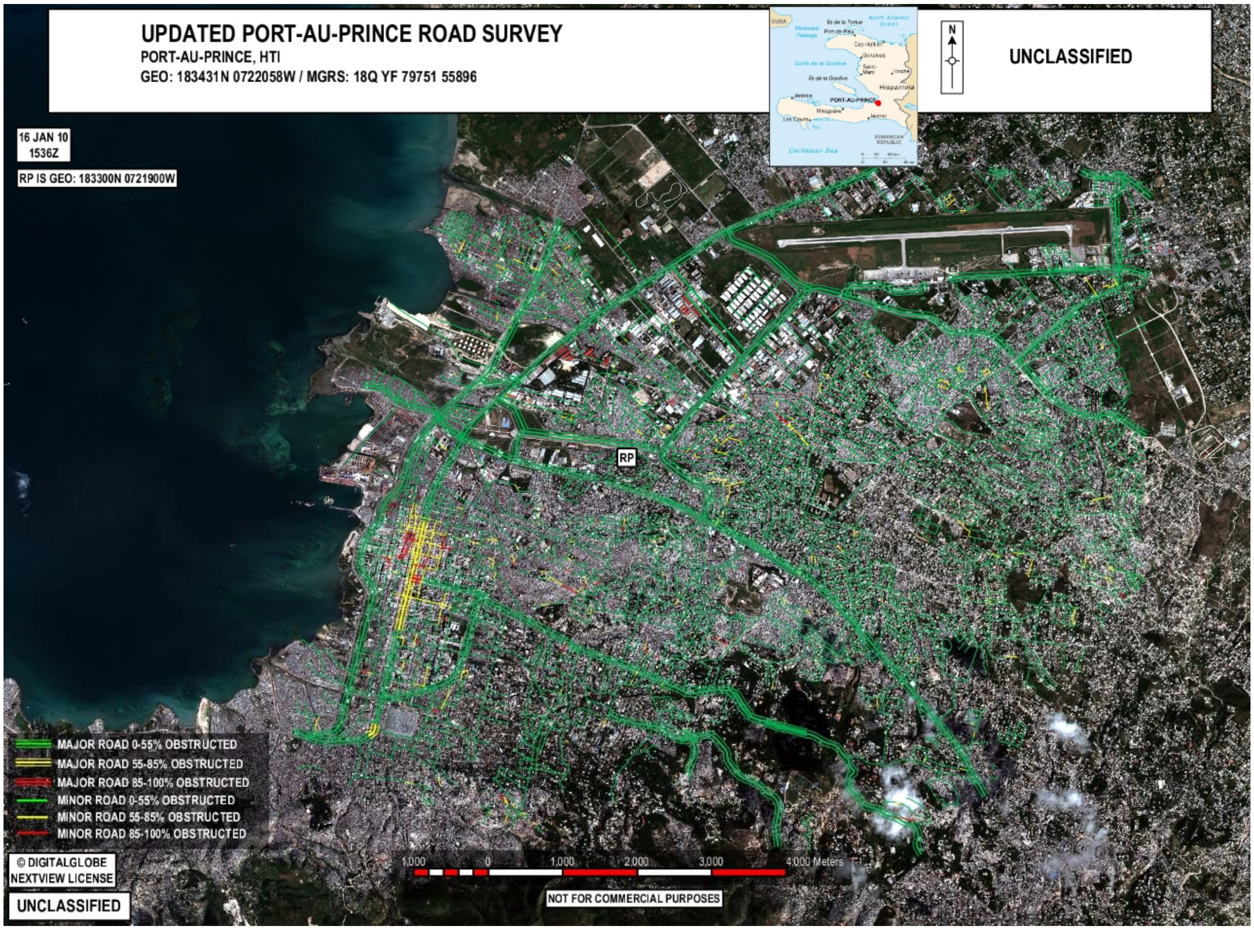

Figure 21. Haiti Earthquake Satellite image[150] with embedded road condition information

This image could have been extrapolated for other uses in various products such as Ushahidi, OSM, Google Earth, Microsoft Virtual Earth, but was not included because of the methods used in its composition. This image was posted on the APAN. Note the lack of GPS coordinate tags except the notation of area covered at the top left of the image. HA/DR teams would have found this image of little value**.**

The 45th Reconnaissance Squadron operating OC‒135B "Open Skies" aircraft (B‒707 variant) out of Offutt Air Force Base, Nebraska, flew several imagery flights 5 days after the earthquake hit Port-au-Prince, Haiti, on January 12, 2010[151] (see figure 38). Northrop Grumman RQ‒4 Global Hawks and Lockheed Martin P‒3 Orions were also used in this effort.

[150] https://community.apan.org/cfs-filesystemfile.ashx/__key/communityserver-components-postattachments/00-00-01-02-53/Updated-Road-Survey_5F00_ALL.JPG
[151] http://www.acc.af.mil/photos/slideshow.asp?id={7649B4DE-E9F4-4F6C-B93C-98C8826E2BBF}

Christchurch, New Zealand, 2010 Earthquake

Ushahidi–Configuration Challenges

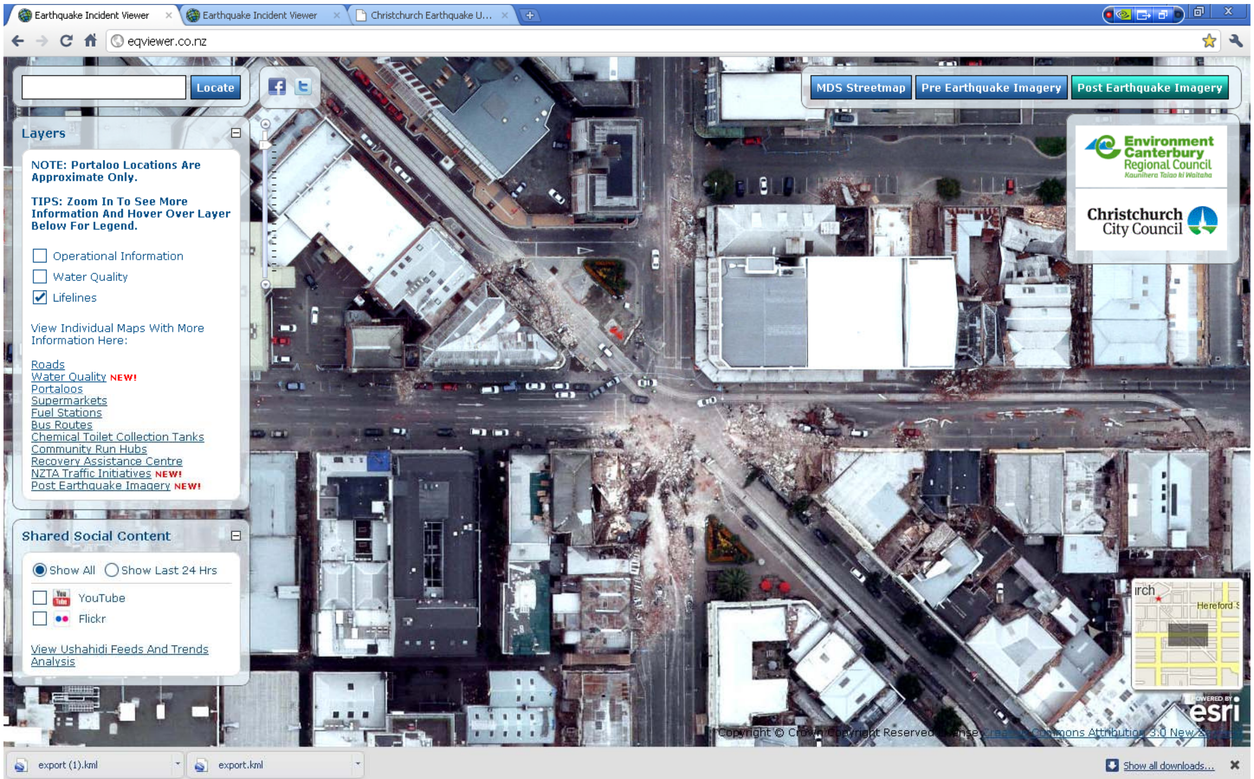

Figure 22, Post 6.3 Earthquake imagery; Christchurch, New Zealand, February 22, 2011[152]

This shows the intersection at Litchfield Street and Manchester Street. Imagery was supplied by the Environmental Systems Research Institute on a website powered by Ushahidi and OpenStreetMap with multiple layers of information available. When a user first visits the site, they will see pre-earthquake and post-earthquake imagery options (top right). This immediately has two effects; the first is the requirement to download two sets of images. This is because the pre-earthquake image has all the street information (see figure 23) and the post-earthquake image shown above does not. The second is that when a user clicks on important information datasets (shown on the left—”Layers”) the user opens a new browsing session, the datasets revert back to pre-earthquake imagery. Again, see figure 23 for example. This is not the fault of the Ushahidi software, but how the administrators configured this particular instance. Careful planning and process steps need to be understood when creating disaster information websites.

[152] http://eqviewer.co.nz/

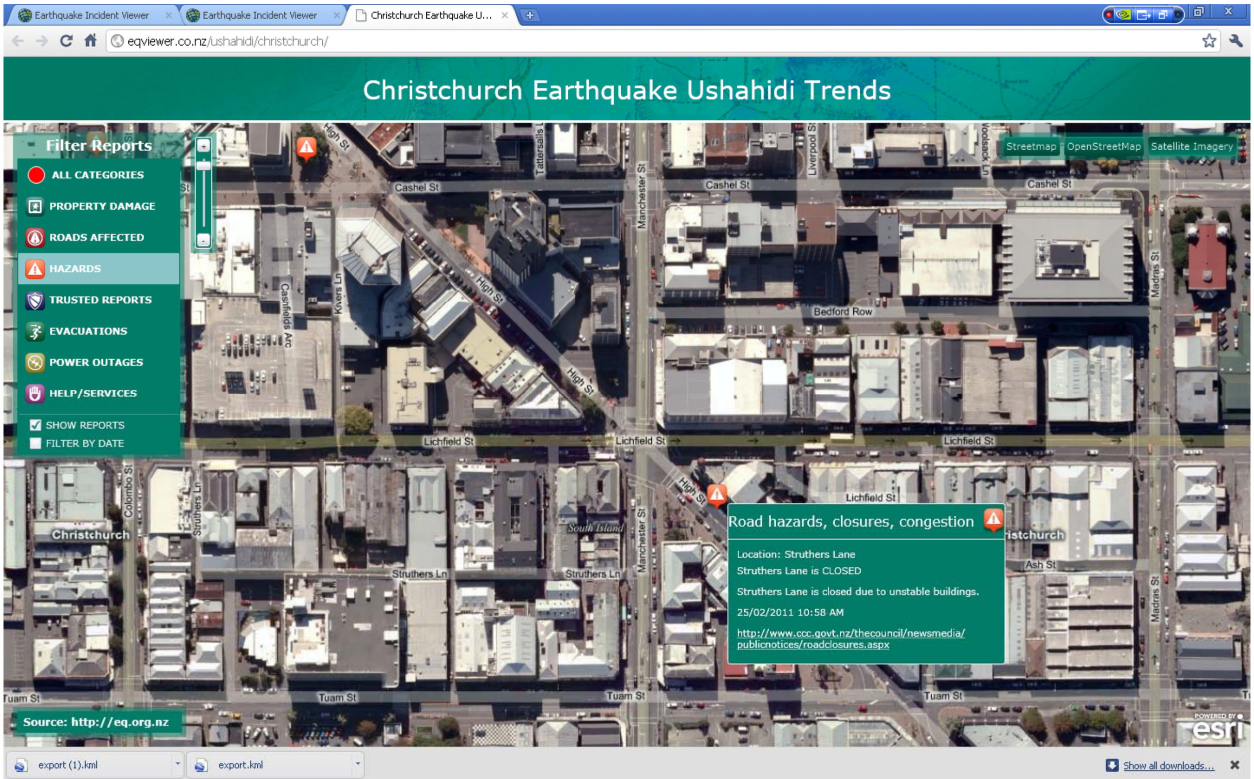

Figure 23. Christchurch, New Zealand, Ushahidi Data Layer specifically for Road Hazards[153]

When a user drills down to the layer desired, in this case road hazards, the information is not layered onto the available post-earthquake imagery. The hazard icon is clickable and brings up a pop-up window describing that nature of the hazard. Had this information been layered onto post-earthquake imagery, several agencies in government, NGOs, and others would have been able to "verify" the information and trust its publication. All the information is available, but the website has several issues to resolve before being labeled "user friendly." Information was parsed from another New Zealand disaster website which deployed the traditional OSM cartography as shown in figure 24.[154]

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153 http://eqviewer.co.nz/

154 *Co-authored by Erik Hersman, Ory Okolloh, Juliana Rotich, and David Kobia in 2008, Ushahidi*[154] *was developed to publish eyewitness accounts of violence occurring during the 2008 Presidential elections in Kenya.* Ushahidi *means "testimony" in Swahili.*

Figure 24. Christchurch, New Zealand, Earthquake Reporting and Analysis site

Volunteer organizations used this site to publish information about resources, conditions, rescue efforts, and government news updates. Other sources included Flickr, Twitter, SMS, Wikipedia, and citizen journalists. Data verification had no governance model and many reports were unverified but trusted nonetheless. This site did not directly use satellite imagery,[155] but much of the information was geospatially referenced.

Note the number of published reports—well over 1,000. The user has the ability to click on one of the listed items in the Table of Contents on the right hand side, which only brings up posts associated with the link. An Urban Search and Rescue (USAR) team could focus on information for their own cachement area. The method typically used today pushes a user request to download the "big picture," then zoom into the area of interest and click on the data points desired. This may still be too much information to digest. Education on how to use the datasets plays a critical role it its value and usage. Many USAR teams now take dedicated IT staff when they deploy for this reason, as do other NGOs and United Nation agencies. While USAR teams do not use this site for team dispatch, it could be used to meet this need.

Information from sources such as Twitter, Facebook, or SMS can be hard to validate when used in websites like this. To help mitigate the risks, a volunteer team manually verified each inbound message prior to publication. More than 300,000 messages were reviewed.[156]

This capability will not exist for every event that unfolds. Imagine trying to verify messages or manage inbound datasets during a major earthquake that may strike on the Asian landmass with the potential of having hundreds of different language dialects to sort and identify.

[155] http://eq.org.nz/
[156] http://vimeo.com/21458456

Tohoku Earthquake and Tsunami 2011

On March 11, 2011, an earthquake measuring 9.0 struck off the coast of Honshu, Japan, creating a tsunami. Together the earthquake and tsunami destroyed or damaged more than 2,200 cellular tower[157] base stations and knocked out over 125,000 landlines. In some regions of the Miyagi Prefecture, entire villages were destroyed and wiped off the map. Telecom carriers responded with the same techniques used for the response in Christchurch, New Zealand. Repairs to critical regions needing wireless communications were completed in a matter of weeks. These repairs continued to be challenging in some areas more than two months later.

In many parts of the world there is clear evidence that high-speed communications systems can be restored in short time frames after disasters. But there are conditions and regions where this type of response will not be possible. The Queensland, Australia, floods of December 2010[158] caused significant damage and limited abilities to repair infrastructure due to the nature of the disaster. Repair times and installation of temporary communications systems were handicapped by the amount of flooding and the time it took for the water to recede. Some regions of South America, Africa, and Southeast and Northeast Asia have limited wireless network infrastructure. The adoption of mobile phone technology in these regions continues to grow at a rapid pace and offers potential when response to a disaster requires its use.

The recent earthquake and tsunami in Japan, a country whose use of wireless communications is extensive, showed an unexpectedly high percentage of old-school text-only 2G mobile phones. This breakdown shows how emergency information should be distributed and in what formats. Several reports (such as those in Table 7) support this view, including Cellular News.[159]

Smartphone and Non-Smartphone Usage: Japan as a Case Study in the Usage of Different Platforms

Analysis of smartphone adoption during December 2010 revealed that 7 million mobile users in Japan (7 percent of the total mobile market) are smartphone owners, an increase of 33.5 percent from September 2010 when ComScore first introduced MobiLens into Japan.

Many smartphones in Japan have advanced capabilities such as mobile wallet, 1seg TV, and waterproof features, all which encourage current feature phone users to switch to smartphone devices.

Table 7. December 2010 Smartphone vs Non-Smartphone Users in Japan

	Total Audience (000)	Share of Total Mobile Audience
Total Mobile Audience	100,900	100.0 percent
Non-smartphone Users (2G)	93,925	93.1 percent
Smartphone Users	6,975	6.9 percent

When looking at smartphone platform adoption in Japan (Table 8), the study found that Apple and Google account for the largest volume of smartphone users. In December 2010, 3.8 million smartphone subscribers used Apple devices, up 48 percent from June 2010. Google Android devices witnessed a surge in users growing to more than 2 million in December 2010, up from just 435,000 users in June.

[157] http://isis-online.org/uploads/isis-reports/documents/Accident_Sequence_Fukushima_31March2011.pdf . This disaster has come to be called the great Tohoku (North-East) earthquake. It also has been called the Fukushima, Honshu, Miyagi, Sendai, etc. earthquake, but this paper uses the term Tohoku.
[158] http://en.wikipedia.org/wiki/Queensland_floods_2010-2011
[159] http://www.cellular-news.com/story/48068.php

Apple, Google, and Microsoft Smartphone Platform Audience in Japan

Table 8. Platform usage: June, September, and December 2010

	Total Audience (000)		
	June-2010	Sept-2010	Dec-2010
Total Smartphone Audience	5,223	5,702	6,975
Apple	2,557	3,347	3,787
Google	435	841	2,174
Microsoft	2,144	1,475	831

Source: Cellular News[160]

The breakdown above illustrates Japanese usage of mobile phones indicating varying platforms used.

In two of these events, Banda Aceh and Haiti, the adoption of newer handheld smartphone devices was limited or not available either because of economic means (Haiti) or not yet in production (Banda Aceh). In New Zealand and Japan, the acceptance and usage of newer technology, while significant, suggests less widespread adoption than expected. The majority of subscribers do not have data plans in use, while others do not know how to use even basic SMS.

After the two earthquakes that hit New Zealand, government leaders pleaded with the Christchurch population to avoid making audio phone calls and instead use text messaging to conserve available phone lines for emergency use for the first 2 weeks after the disaster.

As noted in the core section, transmissions of imagery and crowd-sourced maps[161] were challenging due to limited bandwidth.

Imagery Services in Japan

Duplication of data sets can bring significant cost overruns to a HA/DR imagery program. This can be contained through managed services; operated using centralized and distributed architectures and sound policy planning. Japan has nine different native map suppliers (see tables 9 and 10).

Table 9. Types of Japanese map suppliers

Service	Map	Satellite	Other
Google Japan	Map	Labeled satellite	
Geographical Survey Institute			Topo
CyberJapan			Topo
Mapion	Map		
MapFan Web	Map		
Yahoo! Japan	Map		
Goo	Map		
Its-mo Guide	Map		
Livedoor	Map		

If a user looks up Honda Airport (Japan), 22 different service providers are available in addition to the ones listed here:

160 http://www.cellular-news.com/story/48068.php
161 http://crowdmap.com/

Table 10. Additional Japanese Geospatial Providers which accurately found Honda Airport, Japan

ACME Mapper	Map	Satellite	Terrain, Topo Mapnik
Ayna	Maps	Satellite	
Bing Maps	Map	Aerial	Bird's Eye
Blue Marble Navigator		Satellite	
ExploreOurPla.net		Daily	
Flash Earth		Satellite	
Fourmilab		Satellite	
GeaBios		Satellite	
GeoNames		Satellite	Text (XML)
GlobeXplorer		Satellite	
Google Earth		Open	w/ meta data
Google Maps	Map	Satellite	Terrain
GPS Visualizer	Map	Satellite	Drawing utility
Map24	Map		
MapQuest	Map		
MapTech	Map		
Maps-For-Free	Map		
MSN maps	Map		
NASA World Wind		Open	
Norkart Virtual Globe		Satellite	
OpenStreetMap	Map		more maps, Nominatim (reverse geocoding)
Shaded Relief	Map		
TerraServer		Satellite	
USMapServer	Map		
ViaMichelin International	Map		
Wikimapia	Map	Satellite	+ old places
WikiMiniAtlas	Map		
Yahoo! Maps	Map	Satellite	(Flash required)

Table 9 and 10 Source: GeoHack at Toolserver.org[162]

[162] http://toolserver.org/~geohack/geohack.php?pagename=Honda_Airport&params=35_58_35_N_139_31_27_E_type:airport_region:JP&title=Honda+Airport

Example of Information Overload

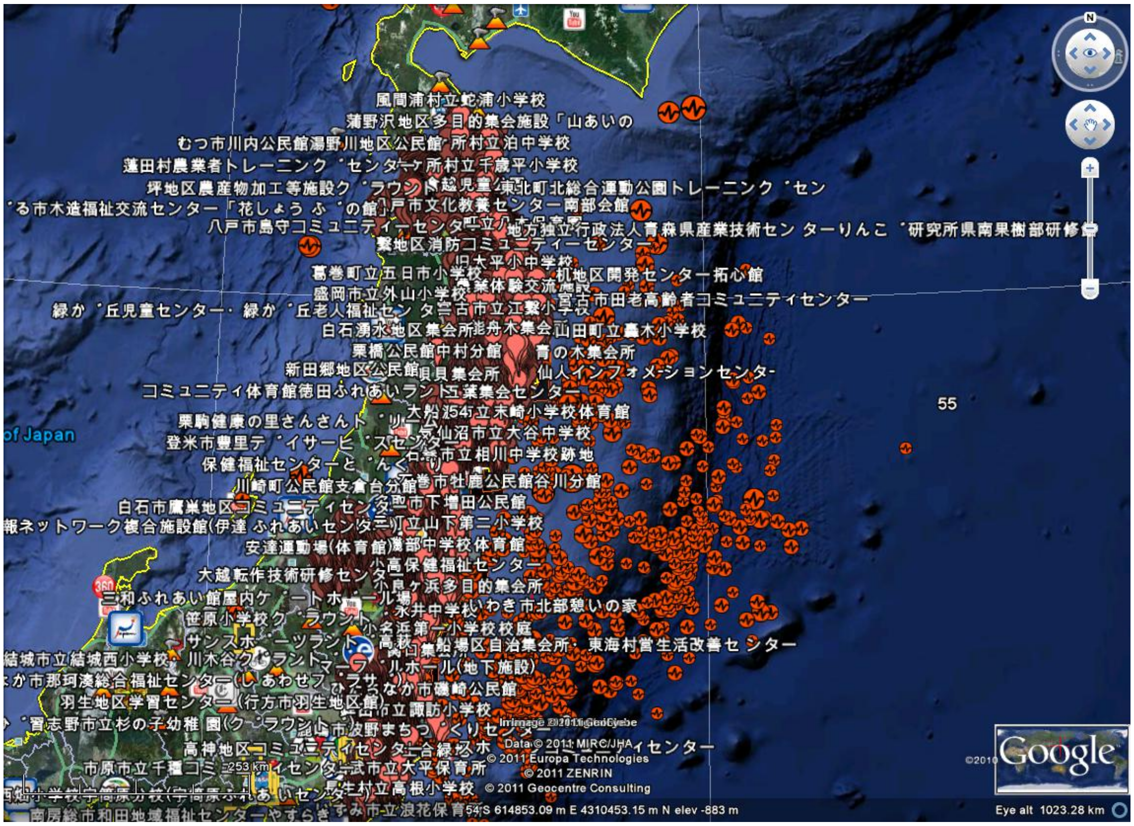

Figure 25. Tohoku Japan Earthquake

This example is taken from the author's computer with multiple KML files open simultaneously using Google Earth.[163] A user can turn off and on each KML "layer" as desired. The user zooms into an area of interest and can click on any source of information ("pins" or icons) to interpret accuracy, verification, or source of information and its contents. Note the size of the Japanese characters. See figure 24 for a supplemental discussion regarding information and imagery overload. The user has control of how many KML files are open simultaneously. As shown in this example, it is easy to see how a map can become confusing with post-event data in multiple languages, multiple reference points, poorly compiled data syllabi, and sometimes duplicated information. But the user has the choice.

This illustration shows 11 different KML files enabled.

[163] http://www.google.com/earth/index.html - Data layers include earthquake aftershocks, twitter feed posts, shelter information, updated satellite imagery, English and Japanese 3rd party source data. Each feed can be turned on and off independently of each other.

Google Earth and Missing Street Names

Figure 26. Satellite Imagery, Sendai, Japan, viewed in Google Earth

Red pins represent shelters. Note Google's lack of street information.[164] Gray lines indicate roads. This image is a composite of two layers of data supplied via KML files. One is the actual red pin data (shelters), the other is the road map. The road information is a Google KML layer while the shelter information is from a third party. A user can copy the characters in the bubble and paste the characters into a translator program such as Google Translate, available in more than 50 languages and used under license from Systran. [165]

[164] http://www.kokuminhogo.go.jp/ - Japan Cabinet Secretariat Civil Protection Portal Site – KMZ file published March 14, 2011

[165] http://www.systransoft.com/

Ushahidi Map– Sendai, Japan

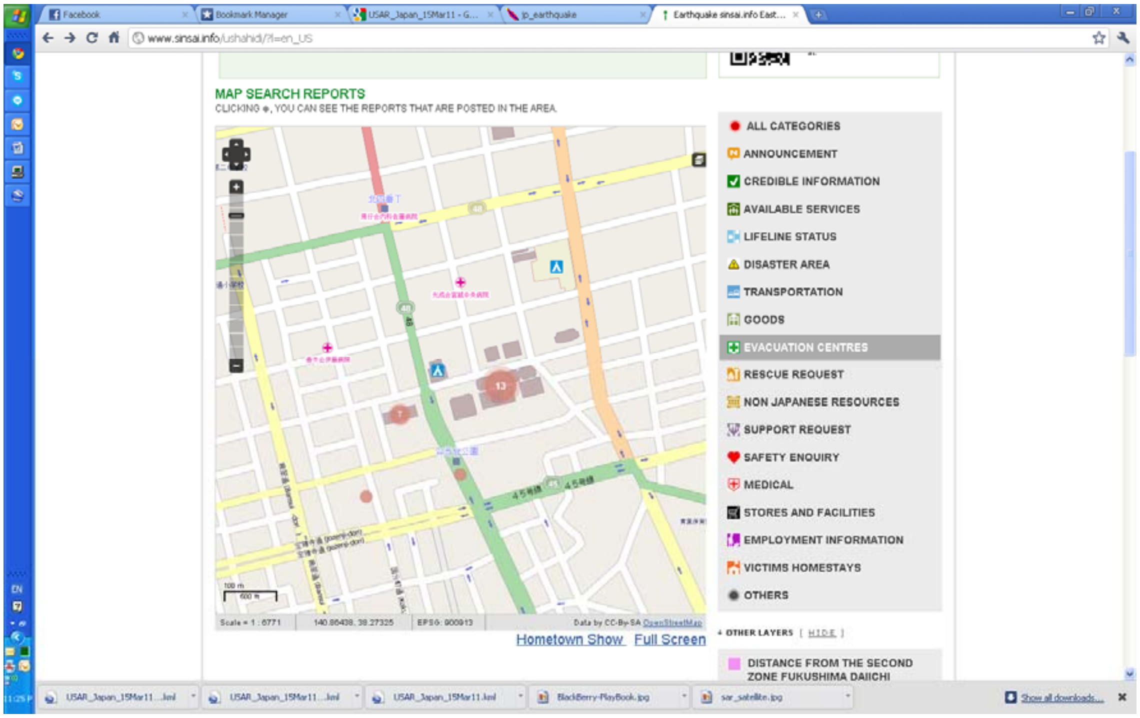

Figure 27. Sendai Japan Ushahidi Website

The same shelter information request in figure 26's Google KML is shown on the Ushahidi site here in figure 27. Note how there is a cluster of information regarding shelters, identified using a orange-red dot with the number 13 in the middle. The next cluster shown lists 7 sources of shelter information to the left of the one identified with 13. This is because the information was not compiled from the same source. A user clicks on the cluster and a new webpage opens up with shelter address, capabilities, status, and services offered. This example of OSM has some street names, while the Google Earth example shown in figure 26 does not.[166]

The administrator(s) of a Ushahidi-powered website have multiple software options. The administrator can add imagery, special topics, and subjects, and offer language options. The site does not have to be built in a single day, but can be modified as information and datasets are supplied to the administrator for publication. Twitter feeds (if used) update in real-time when a Twitter user posts a tweet using #hashtags,[167] which are then automatically pulled into the Ushahidi website. Other API interfaces include publishing shortcode[168] data from mobile phones and SMS text messaging. API development is done through its SwiftRiver program, a collection of APIs that can assist in taking unstructured data and enabling it to be published on a Ushahidi website. Through this API, data can be compiled with GPS coordinates, assigned keywords, and published it in near real-time. This software is open source and freely available to anyone. It integrates with other open source software including Apache Web server, PHP, MySQL, and Ubuntu.[169]

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166 http://www.sinsai.info/ushahidi/?l=en_US
167 http://en.wikipedia.org/wiki/Tag_(metadata)
168 http://www.shortcodes.com/howto_short-codes.html
http://web.acma.gov.au/numb/openAccess/inquiry/viewAllocationSearch.do
http://www.usshortcodes.com/
http://en.wikipedia.org/wiki/Short_code
169 http://wiki.ushahidi.com/doku.php?id=how_to_install_ushahidi#system_requirements

Imagery for Situational Awareness of Ground Conditions

Figure 28. Sendai Airport Japan, 24 hours after the Earthquake & Tsunami[170]

This image clearly shows tsunami damage and residue immediately after the flood water receded from the airport. The runways, taxiways, and main terminal were not usable. Important details showing damage to the airport offers agencies ways to prepare and plan recovery operations or find alternative options in response to the disaster. Any user can retrieve updates and see if conditions are improving. Figure 29 illustrates the progress that was made in 3 days and shows the drying of the apron and taxiways. Using imagery illuminates individual interpretation of conditions that exist and offers remote and localized estimates of response requirements based equal access to identical data.

[170] http://www.google.com/earth/index.html

Google Imagery and Data Sharing – Post Earthquake Example – Sendai, Japan

Figure 29. Sendai Airport Japan. Image taken 96 hours after the Earthquake and Tsunami occurred.[171]

This GeoEye satellite image was published by Google Earth. It is not available for use on applications such as Microsoft Virtual Earth or other Web portals. The raw image itself may not be available from its native source due to legal and contractual obligations to the service bureau. Some GeoEye image sets were available for direct publication and extended use providing all the WGS84 and WMS data points. On March 16, 5 days after Tsunami flooded the airport, the U.S. Air Force 353rd Special Operations Group[172] began repair operations. About 13 days after their arrival, they had cleared the main runway and primary apron, allowing military assistance flights to arrive. Sendai Airport re-opened to civilian flights on April 13th, 32 days after the tsunami struck.[173]

Figure 30. March 29, 2011, Sendai Airport

Airmen from the 320th Special Operations Group, starts military air relief operations. This figure illustrates that communications were down and thus the use of a laptop and whiteboard to manage all flights and ground operations.[174]

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171 http://www.google.com/earth/index.html
172 http://www.353sog.af.mil/
173 http://www.353sog.af.mil/news/story.asp?id=123250695
174 http://www.353sog.af.mil/news/story.asp?id=123249590

United Nations Map − Tohoku Earthquake: Issues in Using KML

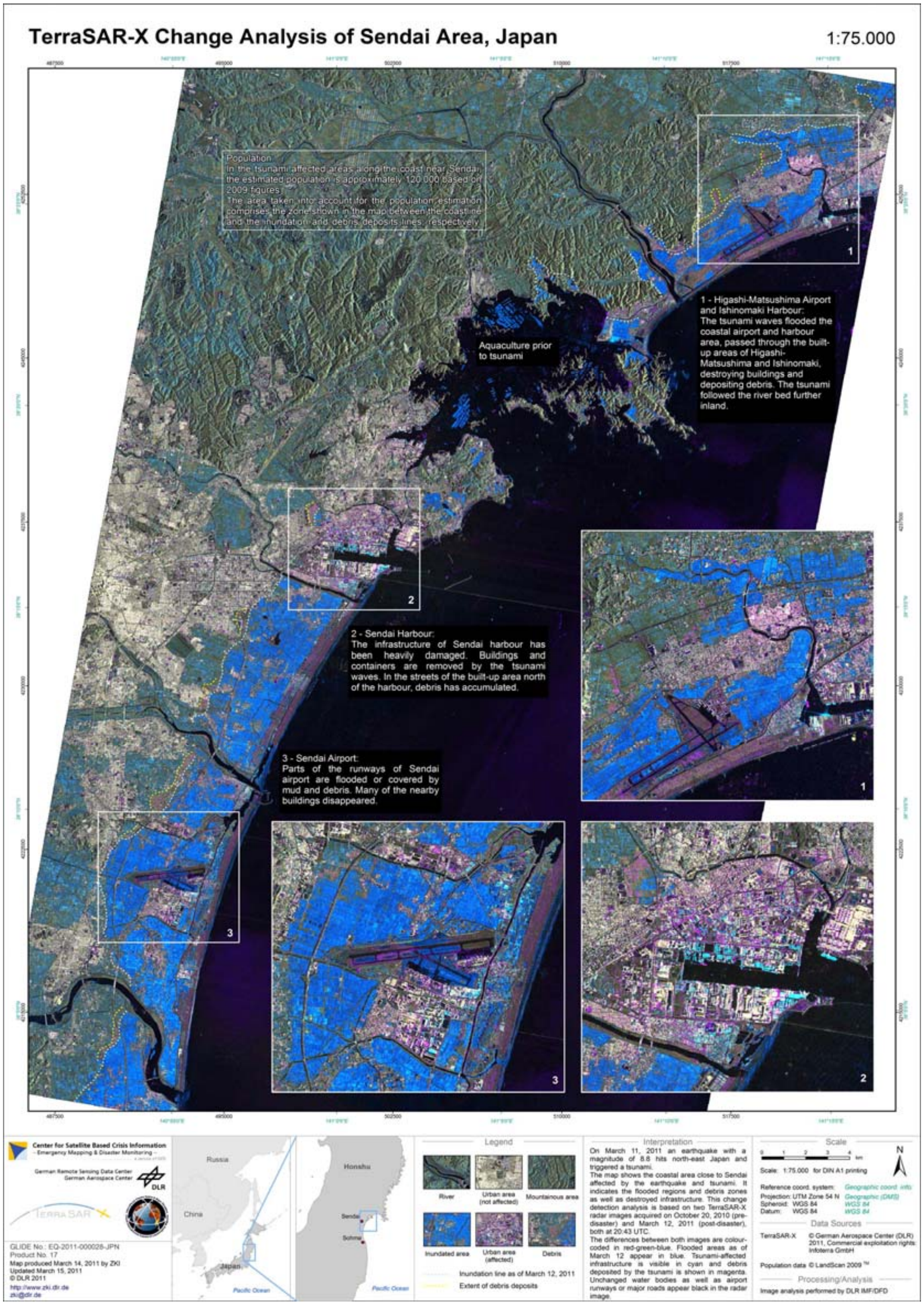

Figure 31. A United Nations compiled Visual Map of Tohoku Earthquake[175]

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[175] http://www.un-spider.org/japan-pacific

The United Nations Space Charter[176], funded and ratified by the United Nations General Assembly in 2006 has successfully provided satellite imagery for many HA/DR requirements such as damage assessment, planning and disaster site conditions. Downloading the United Nations collection of KML files the Tohoku earthquake as a KMZ file exceeds 20 MB.[177] The users at ground zero would not realize this when downloading the file because it does not indicate its size on the site. This file is large for a KMZ and would consume significant transmission time over satellite broadband networks and low speed digital mobile phone equivalents. It must be stressed that KML files do NOT send any imagery to be layered onto the user's cartography application. A user downloads the KML file that behaves like HTML, making requests (link) to a server to retrieve images where they are stored. This is why many KML files no longer work after the disaster is over. The server administrator hosting the images deletes them or archives them elsewhere. This particular KMZ file is hosted on a server in Wessling, Germany, at the German Aerospace Center.[178] The distance between Wessling and Sendai Japan exceeds 6,000 miles routing over 5 different Internet backbone operators before connecting to a local Internet service provider (ISP) or mobile phone provider.

Ushahidi – Tohoku Earthquake – Updated with Bing Map Option

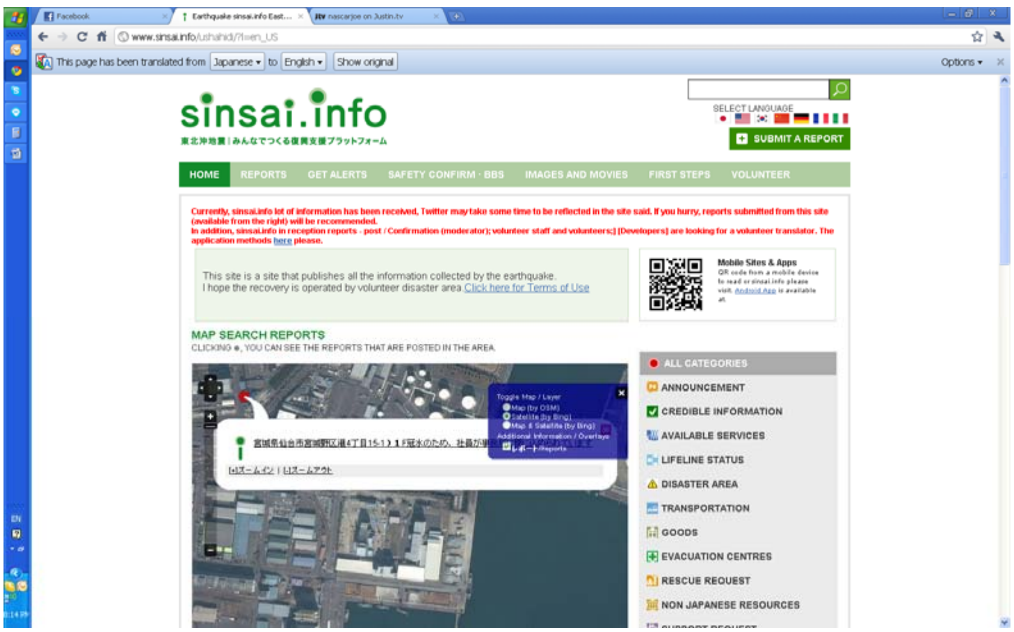

Figure 32

This published version of Ushahidi shows a new metadata layer that a user can enable; Microsoft Bing Satellite image, but not with updated damage (post event) imagery. The post is in Japanese, despite being viewed in the "English" version. Ushahidi accepts KML and KMZ if there is an agreement and technical assistance resources are available. An end user cannot on their own manipulate a Ushahidi portal as an individual, nor can external third party groups unless that group has an arrangement with the principal operators of the site. This offers new collaboration going forward. The majority of Ushahidi disaster portals are operated by volunteer organizations and not government agencies. Note the seven different language options available in the top right of the webpage illustrated as flag icons.[179] Note the use of the Quick Response

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176 http://www.un-spider.org/about

177 http://www.zki.dlr.de/de/system/files/media/filefield/article/download/201103%20-%20Earthquake%20-%20Japan%20-%20Map%20products%20by%20ZKI.kmz

178 http://www.dlr.de/en/

179 http://www.sinsai.info/ushahidi/?l=en_US – The Bing Imagery was not an option when the site first became operational and was updated with this feature 3 plus weeks after the earthquake occurred on March 11, 2011.

icon in the top right of image. The use of such technology will likely become very common. Invented in Japan, it is slowly becoming popular around the world.[180]

Collecting Imagery Depends on the Weather

Figure 33. Satellite Image taken east of Miyagi Prefecture after the Tohoku Earthquake, Japan, March 11, 2011. An example of how weather can block ground conditions.[181]

Aerial imagery may solve some cloud cover constraints, providing it is safe to fly and allowed by the government. Weather impacts the amount of time it takes to collect, sort, and publish the image sets for further manipulation. Depending on the amount of imagery collected during a survey, it can take time to transfer the data from the camera platform to an imagery server. Some systems have shuttle bay hard drives that can be quickly removed and replaced without delay. Transferring the data from the drive to the data center host is then accomplished by remote connection or delivered directly to the facility. Transferring a terabyte of image files can take a significant amount of time if it is accomplished over a network connection. Advanced military reconnaissance platforms transmit imagery via satellite. Most commercial providers do not have access to high-speed satellite data links without incurring significant expense.

[180] http://en.wikipedia.org/wiki/QR_code
[181] http://hyperquad.telascience.org/jp_earthquake/

How Imagery Overload Occurs – The Domino Effect

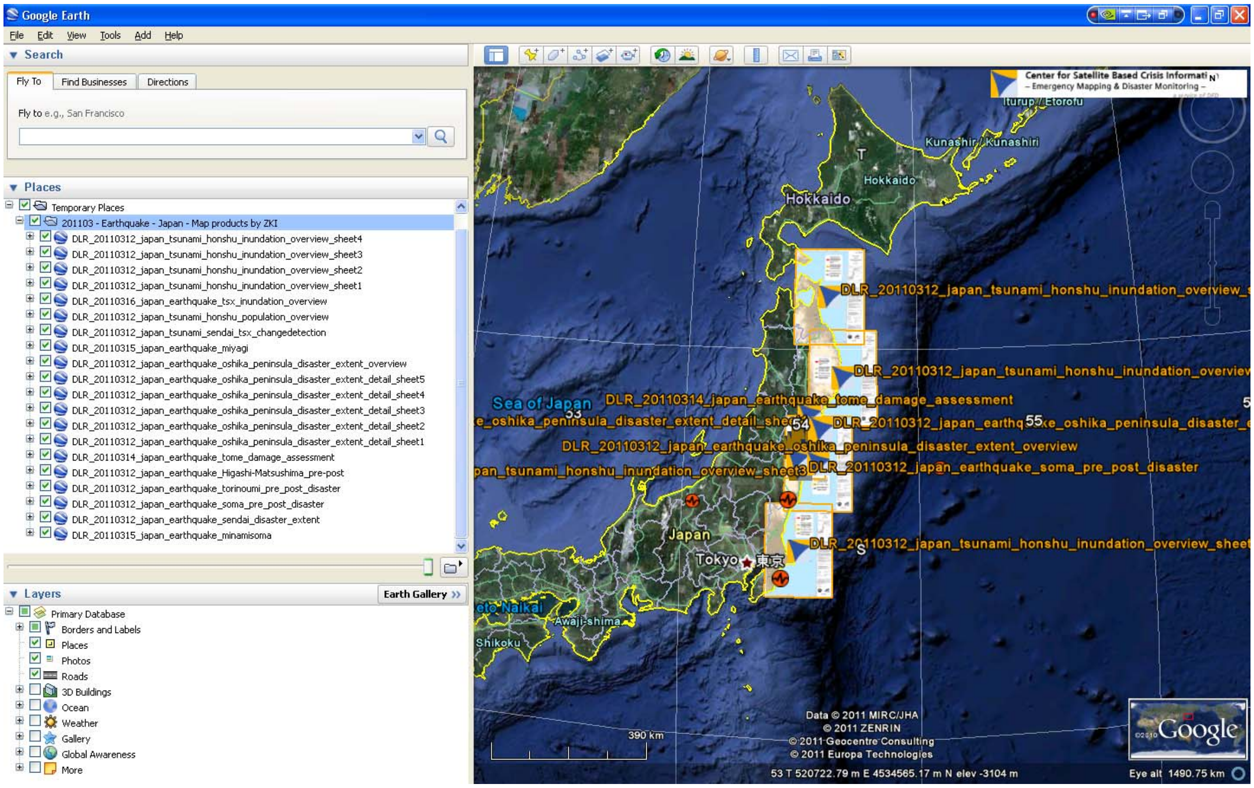

Figure 34. UN-SPIDER KMZ file for Google Earth

This set of KML files illustrates how imagery overload can occur. Using the approach described in figure 14, the UN compiled all relevant KML files into a single compressed archived for download at approximately 20 MB in size. Included were layered maps to use on Google Maps or Google Earth. Note on the left hand side where all the KML layers that are included in the KMZ file are listed. At a very high "altitude" the information contained within each KML appears to be a simple overlay of cartography maps that are properly aligned to Google Earth's virtual map. No other KML files are open other than the ones contained within the KMZ file itself. All Google add-on database layers are turned off as shown in the bottom left except those that assist in visualization of where a user is relative to the data overlays used. In this case, roads, places, and any relevant photos that assist user orientation were shown.

A user can turn off each layer of information supplied by the UN Space-based Information for Disaster Management and Emergency Response (SPIDER), then zoom into the appropriate sector of the map the user is interested in. Note the file names associated on the map itself, assisting the user in identifying which map applies to each relevant KML file. Not all developers of KML follow this cardinal rule, leading to time loss by the users as they experiment with which layers to turn on and off.

These layer map add-ons are not updated imagery layered on top of Google's virtual world. They are traditional cartography maps that explain why the KML/KMZ file was so "small" at 20 MBs. Had the UN team used updated real-time imagery, the file sizes would have been hundreds of megabytes if they tried to cover the same area. This induces a dilemma facing all users of imagery, particularly those in the field where access to Internet connectivity may be limited. This example illustrates why it is critical that KML/KMZ downloads be properly described and portrayed prior to use and download. Authors and website administrators must invest time to publish these details using an HA/DR syllabus and references that will help the user retrieve only information relevant to their needs. The need for post-event aerial and satellite imagery should also be available as overlays, with care and attention to how big these KML files can grow.

Suggestions include sector definitions by name of the region, description of layered information, date, source/publisher, instructions, and more. All must be considered when publishing a KML/KMZ.

When using post-event imagery, the grids (tiles) available must be published in smaller file sizes, enabling ground staff to download only what they need and not be required to download large regions of little interest. Authors may be required to create multiple KML files using the same post-event imagery to be used by different user groups with different needs instead of one master KMZ compressed file showing everything available. The ideal scenario is one that allows users to download appropriately sized RAW (unedited without markup) post-event imagery as a file in itself, ensuring large imagery files only need to be downloaded *once* for each region. Publishers of supplemental data (such as twitter feeds, shelter information, and logistics centers) are then added as new layers (for specific use in each region or grouping of image layers supplied) independent of the post-event image(s) KML file. This allows specific information that the user wishes to obtain as specialized components while limiting the impacts of excessive information being downloaded. It is critical to note that publishers of layer datasets should be prepared to furnish data in the country's native language and of those assisting on the ground. Datasets can be grouped by relevancy such as search and rescue data and then distributed.

Mapping Standards: Government Use of KML

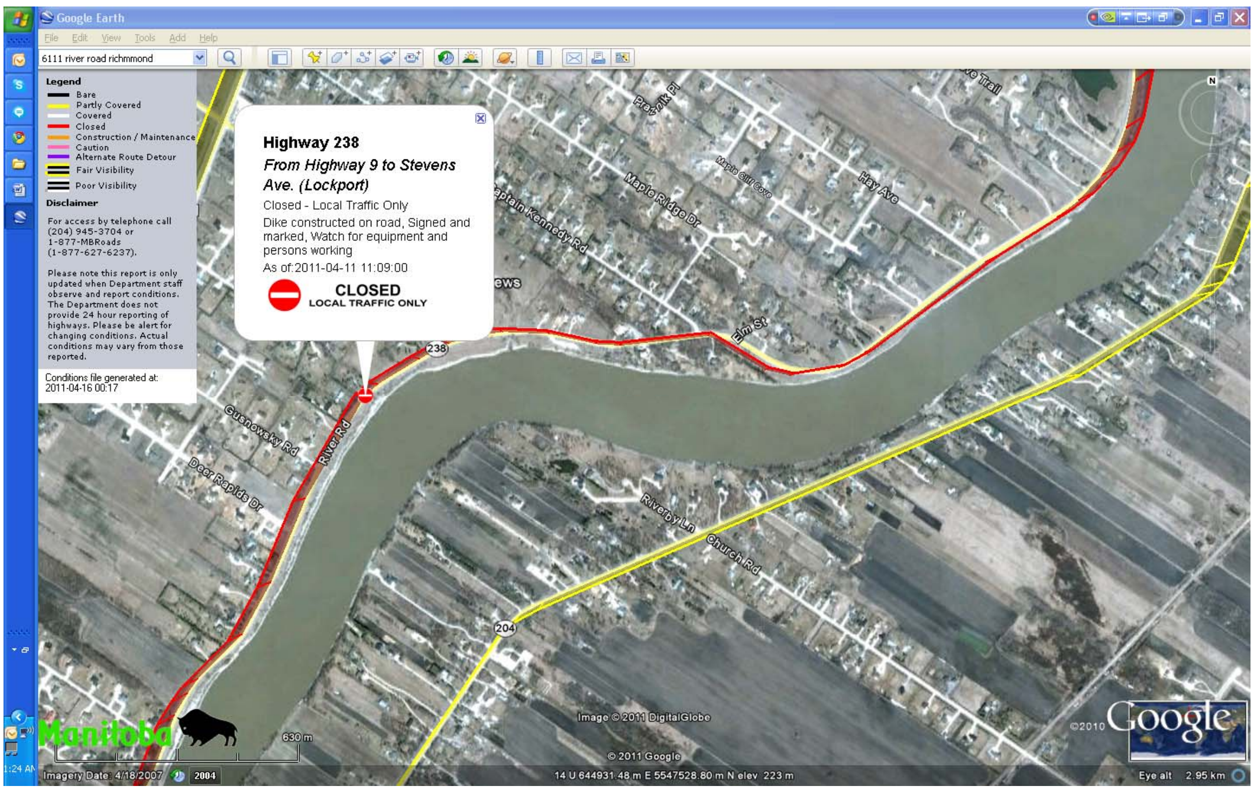

Figure 35. Manitoba April 2011 Flood

Some governments are beginning to endorse the use of KML for applications like Google Earth. Note the legend on the left hand side. It demonstrates distribution of important information in addition to what each reference point represents. If developers follow these policies and guidelines when publishing datasets, the value of their work increases. Highlights include date of file publication, additional information resources available, and disclosure of what risks are involved in interpretation and use of the information compiled. The pop-up window describes appropriate information relative to the authors' intent, in this case, highway conditions for this section. This KML file was published by the Ministry of Transportation (Manitoba) April 16th, 2011.[182]

[182] http://manitoba.ca/flooding/roadinfo.html

Note that post flooding satellite imagery was not used. Even though the flooding has affected large areas and is causing significant economic damage and logistics challenges, the province has sufficient communications resources to ensure the public is informed of essential information as it occurs. This avoids the cost of contracting a service bureau for post flooding images.The Transportation Ministry also exported identical data to its Twitter account.[183] They used the KML data on their website map that uses Google Maps without satellite imagery.[184] The flood "season" affects three provinces and is monitored between March and May of each year.[185]

http://roaddata.gov.mb.ca/map/gearth/kmz/manitobahighwayconditions_e_kmz.kmz

183 http://twitter.com/MBGov

184 http://roaddata.gov.mb.ca/map/gmap/map.aspx

185 http://news.gov.mb.ca/news/index.html?archive=&item=11084

National Oceanic Atmospheric Administration (NOAA) – British Petroleum Deep Water Horizon, Gulf of Mexico

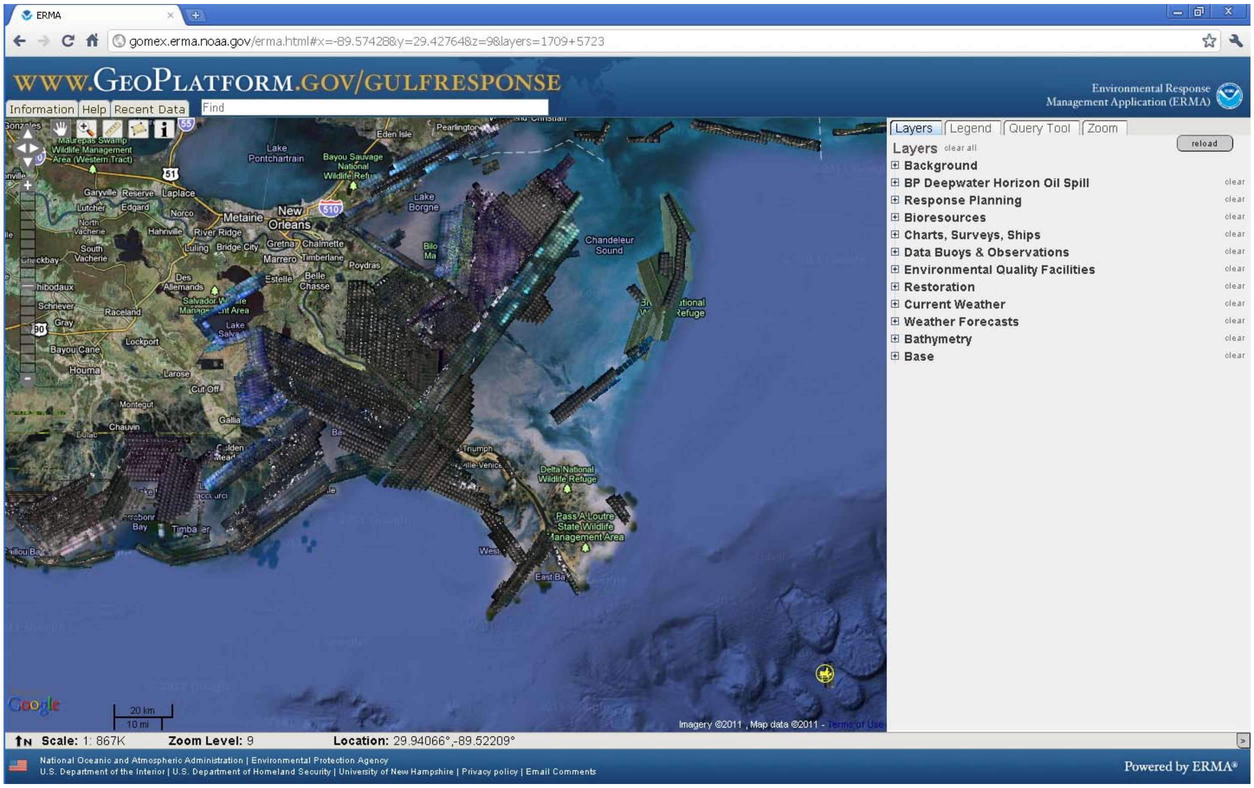

Figure 36. British Petroleum Deep Water Horizon Disaster April 20, 2010 Website[186]

The National Oceanic Atmospheric Administration (NOAA) in collaboration with the University of New Hampshire developed the Environmental Response Management Application platform to monitor, collect, and optimize environment imagery datasets. This website became one of the primary sources of information for government and non-government agencies consisting of observers, leaders, contractors, volunteers, and the general public to understand fully the challenges that would occur over the next 3 months before the oil well (shown as a yellow icon in lower right corner) was capped. Note on the right hand side how the site's administrators put together the table of contents offering concisely formatted information sets for a user to navigate. Each section offers expansion to imagery options and information layers as required by the user. In this particular screen shot, all imagery tiles have been highlighted to illustrate how many post-disaster aerial and satellite missions were undertaken.

The team focused on pertinent data required and requested by its member audience and published it on the Internet. Historically, access to this amount of data and reference information was unprecedented. The NOAA and other U.S. federal agencies monitored more than 86,000 square miles of ocean and coastal regions impacted by the estimated release of 4.9 million barrel equivalents of crude oil into the Gulf of Mexico.[187]

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[186] http://gomex.erma.noaa.gov/erma.html#x=-89.57428&y=29.42764&z=9&layers=1709+5723 – image created by the author using Chrome Browser. Location: South of New Orleans, Louisiana

[187] http://en.wikipedia.org/wiki/Deepwater_Horizon_oil_spill
http://www.pbs.org/newshour/rundown/2010/08/new-estimate-puts-oil-leak-at-49-million-barrels.html

The Use of a Web Map Service

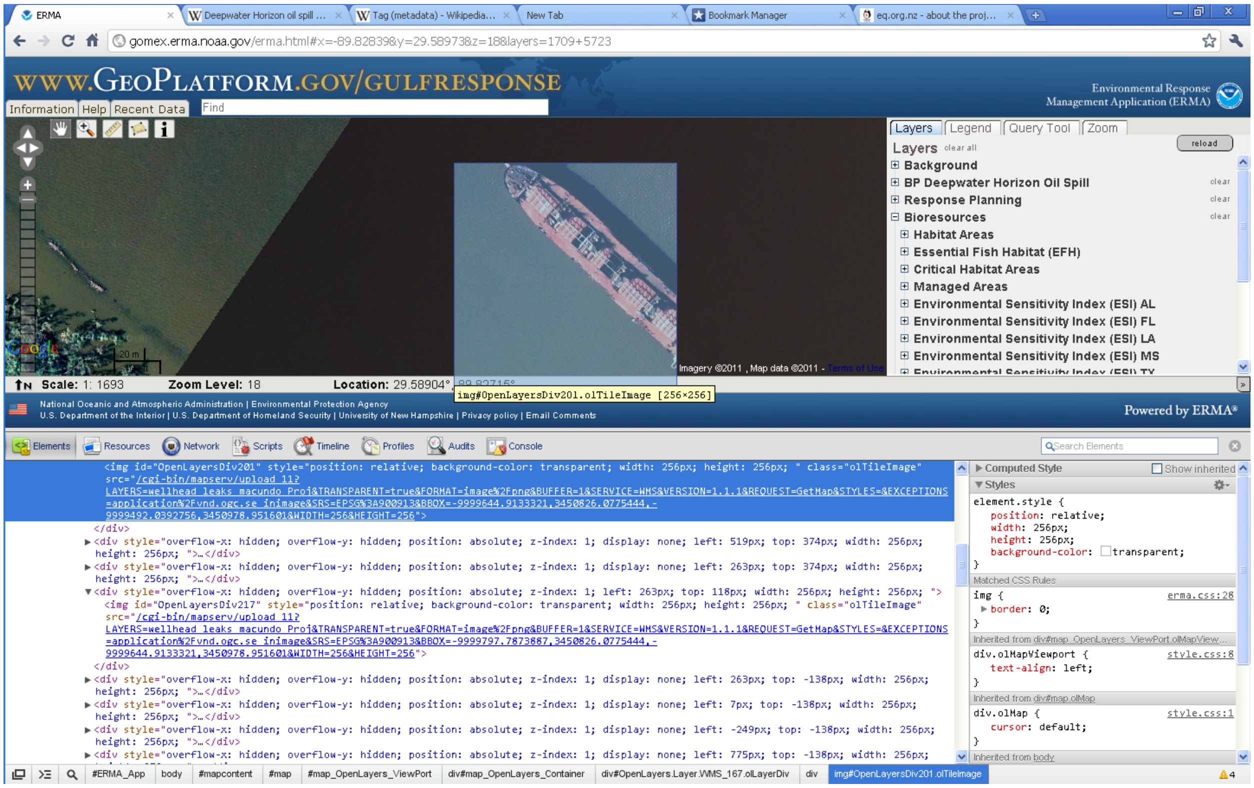

Figure 37. Base Imagery beside post-event imagery, Mississippi River, New Orleans, Louisiana

Figure 37 illustrates how a WMS indexes, sorts, and identifies different layers of imagery. The sample tile is highlighted in light blue. How it is scripted on a WMS server is highlighted in medium blue in the Elements section which in turn highlights the map tile attached to the script (cargo ship) in the middle of figure 31. Note the equal resolution quality of prior and post-event imagery. The highlighted light blue image tile clearly shows the shadow of the ship in transit on the Mississippi River near Bass Road and Highway 15 illustrating the quality of the image. The contrast between where the ship is and just left of its location in the upper left corner clearly shows before and after oil damage in the river identifiable by the different colors of the water. The upper left hand corner tile / image had not been updated with oil spill damage imagery.

Aerial Imagery Platforms

Military

Figure 38

U.S. Air Force OC−135B Open Skies observation aircraft similar to this one,[188] with four camera bays at rear of aircraft (visible under the U.S.A.F. star insignia) flew several sorties over Haiti from Andrews Air Force Base to assess damage. Of significant interest is the way in which the imagery was made available:

"Within the confines of an "Open Skies" treaty mission the imagery is unclassified, but not for general public release. For humanitarian support, the imagery is releasable and will be made available to the Department of State for use in its overall humanitarian assistance mission and to the public."[189]

Government aircraft are expensive to operate and have strict regulations and security policies that impact the value of the imagery collected and made available to NGOs and IOs needing it. Not all governments have the same regulations in place. There are cases where U.S. technology used in non-U.S. military aircraft (and satellites) is restricted, even if operated by a nation other than the United States, due to technology transfer restrictions agreed to when sold for imagery use. [190]

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[188] http://www.worldwide-military.com/Military%20Aircraft/Electronic%20Warfare/OC-135_english.htm
[189] http://www.dtra.mil/NewsMultimedia/NewsArticle3.aspx
[190] http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=c5cc9a1c749a6f225283bdfa124431d0&rgn=div9&view=text&node=15:2.1.3.4.45.0.1.3.87&idno=15

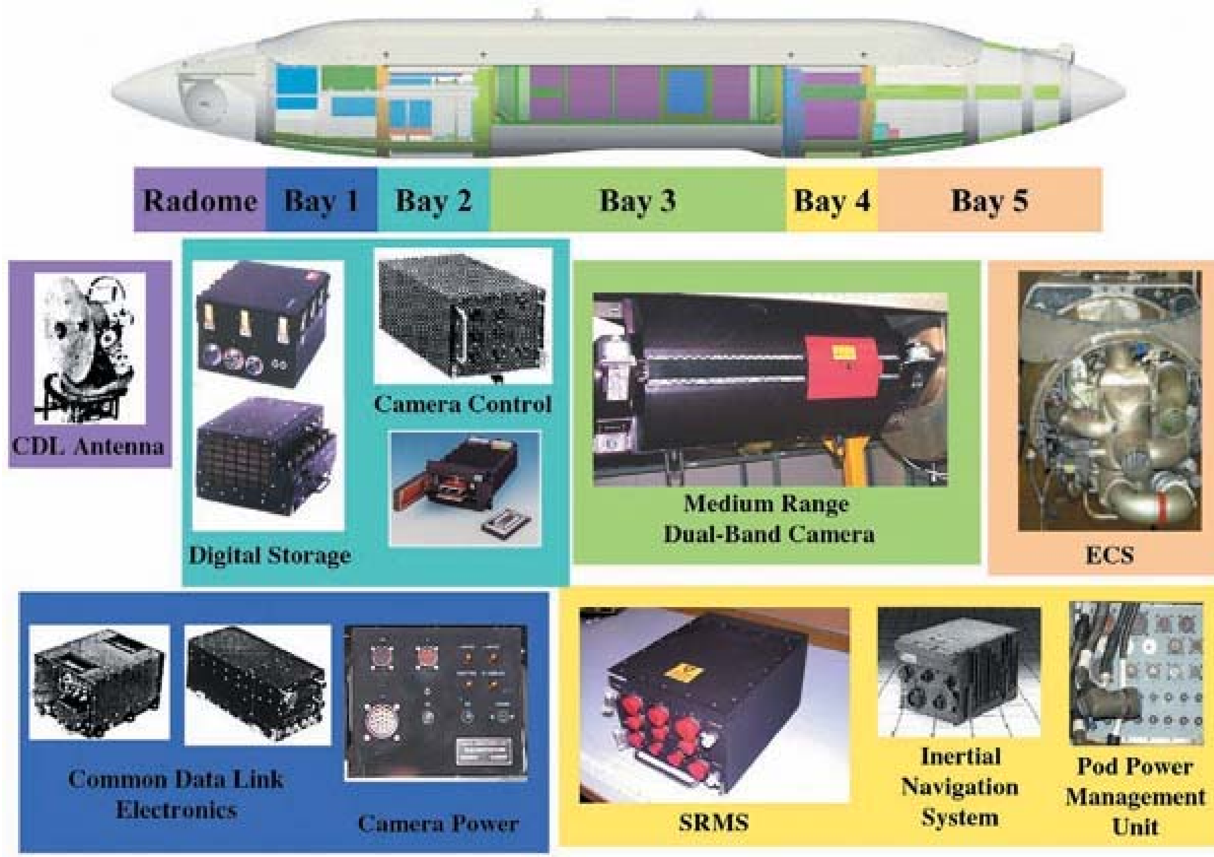

Figure 39. Raytheon Shared Reconnaissance Pod[191]

Beginning in 2001, the U.S. Office of Naval Research began development of the replacements for film-based imagery systems. This platform has been in service since 2003. This Raytheon Shared Reconnaissance Pod was installed on a U.S. Navy F–18 during the Tohoku earthquake that struck Japan on March 11, 2011, and recorded more than 45,000 images. The pod incorporates a Goodrich CCD CA–270 Dual Band Infrared and Visible camera. It is not known if the visible 5040 x 5040 JPEG-compliant images are formatted (or available) with WGS84 metadata. Analysis suggests that it is possible to do so through software processing.

The majority of G–20 nations have this capability provided by the military or other federal level agencies. Nations with publicly known military aerial reconnaissance units are:[192]

Australia	Canada	France	Germany	Greece	Israel	Japan	Netherlands	Philippines
Portugal	Russia	Sweden	Serbia	United Kingdom	United States			

[191] http://www.nrl.navy.mil/research/nrl-review/2002/optical-sciences/duncan/
[192] http://en.wikipedia.org/wiki/List_of_reconnaissance_units

Civilian and Commercial

Figure 40. Commercial Aircraft with Dedicated Camera Platforms installed such as this Beech King Air 350[193]

Commercial digital mapping services today are a commercially viable business. Newer systems are, in some cases, more technically advanced than some military platforms in use today. These advanced commercial technologies are not available in all regions of the world. Typically turboprop or piston aircraft are used, which limits range and extends the time before an aircraft can be on station to begin operations. Popular aircraft such as Cessna C−150/172 up to a Beech King Air 350 are the most popular.

Figure 41. Zeiss Jena LMK 2000 Mapping Camera system installed in a Cessna Single Engine T−206[194]

This system was not integrated into the aircraft flight management system. It is gyro-stabilized. It records the required GIS metadata with its independent GPS navigation system. This particular system is configured for localized imagery capacity and is restrained by the aircraft's range and payload limit.

A very few commercial imagery bureaus operate pure twin-engine jet aircraft with extended range and payload capabilities to deploy anywhere in the world and be on station within 24 hours of a request.

[193] http://www.hawkerbeechcraft.com/military_and_special_mission/flight_insp_camera.aspx
[194] http://www.georgiaaerial.com/equipment.htm

Commercial Aerial Digital Imagery Products

Figure 42. Leica PV−80 Gyro Stabilizer Used for Aerial Imaging[195]

This accessory helps compensate for angular deviations in addition to the constant changes in pitch and roll experienced in flight. Not all aerial imaging service bureaus have this technology due to the costs associated with installing it in conjunction with the digital imaging equipment and the Flight and Sensor Control Management System[196] that can be integrated into the camera and the aircraft's flight control management system. Leica offers several advanced digital imaging systems that are used worldwide.

Figure 43. Intergraph Digital Mapping Camera[197]

Intergraph's Digital Mapping Camera (DMC) is capable of recording digital images at altitudes ranging from 500 to 8,000 meters. The system is gyro stabilized like the Leica system.[198] When first developed, government agencies were the only clients that could afford them. Today, they are becoming widespread and used for specific commercial purpose such as mapping surveys for hydro grids, transportation providers and content publishers like GeoEye and Google. In 2008, Google signed an exclusive mapping imagery contract with GeoEye with the launch of the GeoEye 1 satellite that orbits 423 miles above the earth. Resolution is limited to 50 centimeters due to legal contract restrictions with the U.S. Government. Google augments its high resolution and on-demand imagery with DMC technology operated and managed by GeoEye.

[195] http://www.leica-geosystems.com/en/Airborne-Sensors-Leica-PAV80_70926.htm
[196] http://www.leica-geosystems.com/en/Airborne-sensor-related-software-Leica-FCMS_65491.htm
[197] http://www.intergraph.com/
[198] http://www.intergraph.com/photo/default.aspx

Figure 44. Vexcel Ultracam XP Imaging System[199]

Vexcel's platform is used for mapping applications including Bing maps. Microsoft acquired the company in 2006.[200] This system uses advanced management and system software. The specifications are:

- Image Source Vexcel Imaging UltraCam
- Image characteristics 8U 10000P x 10000L x 3Channel
- Image file size 259 MB avg. (68 images)
- Resolution 7.5 centimeters
- Ortho Processing Speed Up to 27 sec/image/GPU*
- Orthos per Day on GXL Aerial Up to 4700 scenes/day (1.2TB/day) Parallel Processing*
- OrthoMosaic Full Workflow Speed Up to 14m 32s /image/Processor*
- OrthoMosaic per Day on GXL Aerial Up to 1797 scenes/day (465GB/day) Parallel Processing*

*variable; depends on workflow and systems used to integrate to the Vexcel platform.[201]

199 http://www.microsoft.com/ultracam/en-us/UltraCamXp.aspx
200 http://www.microsoft.com/presspass/press/2006/may06/05-04VexcelPR.mspx
201 http://download.microsoft.com/download/0/F/D/0FD2DF56-9F51-4516-B83C-F0200AE3DBEE/UltraMapSoftware-LTR-0727-WEB.pdf - *descriptions used are marketing names for the Vexcel platform.

Glossary

Adobe (Systems): Software publisher best known for its Adobe Reader and Shockwave document and multi-media application products. It has been criticized for computer processing demand, bandwidth requirements, and problematic security holes. Founded in 1982 by John Warnock and Charles Geschke to develop postscript page languages for computers used for desktop publishing, it branched out and acquired several companies specializing in multi-media applications and services including Macromedia—the developer of Flash and Shockwave.

All Partners Access Network (APAN): An information exchange portal funded by the United States Department of Defense originally developed in 1997 as a Virtual Information Center within U.S. Pacific Command (USPACOM) under Admiral Dennis Blair. A major focus is on Humanitarian Assistance cooperation between military and civilian organizations. Originally known as the Asia-Pacific Area Network.

Application Programming Interface (API): A software interface that interacts between two or more different sets of design and programming rules and allows each to communicate, share, and transfer information between the different operating (software) and hardware (platform) systems.

Apple: Apple Computer Corporation co-founded by Steve Jobs, Steve Wozniak, and Ronald Wayne. One of the largest manufactures of computers, personal multi-media devices, wireless phones, and next generation consumer tablet computers.

Android: A computer operating system based on the Linux Open source (operating system) designed for mobile phones. (see Linux)

American Society for Photogrammetry and Remote Sensing: United States-based oversight organization for imagery and cartography standards for equipment founded in 1934. Member of the International Society for Photogrammetry and Remote Sensing.

Banda Aceh: Provincial capital on the island of Sumatra in Indonesia that was hit by a catastrophic earthquake and tsunami on December 26, 2004.

Broadband Global Area Network (BGAN): Four geostationary satellites in low earth orbit used for Internet and Voice Networks covering 95 percent of the globe. Developed by Inmarsat in 2005.

Blackberry: Research In Motion's mobile phone product line. Considered to be the first mass produced multimedia smartphone in global production, now used by governments, and enterprise and consumer markets.

Charge-Coupled Device (CCD): A silicon-based element used in capturing light - photo-electrically that can be recorded and converted into a digital photograph. A key component in the replacement of film based image recording.

Canadian Geographic Information System: Standard for geographically referenced information first developed in the 1960s by the Canadian Government. See Geographic Information System (GIS).

COPAX: Economic Community of Central African States. A union treaty established in 1966 that includes mutual assistance agreements between member nations. Signatories include: Cameroon, Central African Republic, Chad, Republic of Congo, Equatorial Guinea, and Gabon.

CrisisCommons: An all-volunteer organization consisting of software and technology experts who donate their time and expertise with a primary focus of assisting and collaborating with government and non-government entities when a disaster strikes creating solutions that share information and knowledge of the event for use by any organization or agency.

CrisisMappers.net: A group of volunteers who deliver technical and social software application expertise during a disaster with a focus on mapping. This group was present in recent disaster events such as the earthquakes in Haiti; Christchurch, New Zealand; and Tohoku, Japan. The group was created by Patrick Meier and Jen Ziemke and currently has about 4,500 members.

Collective Security Treaty Organization (CSTO): Inter-government cooperation alliance established in 1992 after the collapse of the Warsaw Pact. Members include: Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, and Uzbekistan.

Civil Defense: As defined by DOD Joint Publication 1-02: All those activities and measures designed or undertaken to: a. minimize the effects upon the civilian population caused or which would be caused by an enemy attack on the United States; b. deal with the immediate emergency conditions that would be created by any such attack; and c. effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities destroyed or damaged by any such attack. Additional civil terms used by DOD available for download at: http://www.dtic.mil/doctrine/new_pubs/jp1_02.pdf

In Canada, Public Safety Canada's roots in civil defence describe their mandate as:

Our mandate is to keep Canadians safe from a range of risks such as natural disasters, crime and terrorism.

Since 1951, Emergency management doctrine and organizational change has occurred 5 times within the department.

Public Safety Canada works with other levels of government and operators of critical infrastructure (such as utility companies) to help ensure essential services will be available to Canadians during an emergency.

See: http://www.publicsafety.gc.ca/abt/wwd/index-eng.aspx

New Zealand's Civil Defence role: The Ministry of Civil Defence and Emergency Management leads the way in making New Zealand and its communities resilient to hazards and disasters. The overarching strategy for achieving resilience to hazards and disasters is through a risk management approach to the four "Rs" of: Reduction, Readiness, Response, Recovery.

See: http://www.civildefence.govt.nz/memwebsite.nsf/wpgURL/About-the-Ministry-Index?OpenDocument

Code Division Multiple Access (CDMA): CDMA is a "spread spectrum" technology, allowing many users to occupy the same time and frequency allocations in a given band/space. CDMA assigns unique codes to each communication to differentiate it from others in the same spectrum. In a world of finite spectrum resources, CDMA enables many more people to share the airwaves at the same time than do alternative technologies. Also known as CDMA2000. CDMA also stores its subscriber authentication information on the carrier networks servers, not in the phone itself. Quick facts:

- 334 commercial operators
- 123 countries/territories
- 322 commercial CDMA2000 1X networks
- 122 commercial 1xEV-DO Rel. 0 networks

- 137 commercial 1xEV-DO Rev. A networks
- 9 commercial EV-DO Rev. B networks
- 614,020,000 CDMA2000 subscribers (2Q 2011)
- 185,890,000 CDMA2000 1xEV-DO subscribers (2Q 2011)
- 2,984 devices have been introduced in to the market

(as of January 30, 2012) See: http://www.cdma.org

Coordinate Reference System (CRS): A coordinate's standard to locate geographic reference points so they can be used in GIS.

EPSG−900913: A mapping standard used by Google Maps. Uses World Geodetic System(WGS)84 as its baseline. It is modified to be used on Google's Map application and is used by Google, OpenStreetMap, and Microsoft Bing Maps. It is based on a Spherical Mercator Projection.

Emergency Operations Center (EOC): A centralized command and control center, coordinated between various levels of government organizations, and is activated during a civil or disaster situation.

EDGE: Enhanced Data GSM Evolution. Next generation mobile/wireless network protocol used to communicate between a radio tower and handheld or small form-factor devices for voice and data communication links. Used widely in Europe. See GSM.

Facebook: The largest social media portal in the world with more than 600 million users. Developed and founded by Mark Zuckerberg, Eduardo Saverin, Dustin Moskovitz, and Chris Hughes in 2004.

Geography Markup Language (GML): An Extensible Markup Language (XML) program interface to extract and place geographic objects (or user created polygons) that can be referenced and placed onto a digital map source. GML also has other cartography application usages.

Geographic (Geospatial) Information System (GIS): The capability to layer or merge information onto a cartography map. The map is the foundation in which external data (also known as metadata) references the source's location in one or all of the following commonly used dimensions: time (past, current or future), geometric size in two or three dimensions (expressed as width, length and height), reference points and scale (numeric volume and/or velocity).

GDACS: Global Disaster Alert and Coordination System. United Nations designed emergency management platform. The UN describes it as: GDACS is a cooperation framework under the United Nations umbrella. It includes disaster managers and disaster information systems worldwide and aims at filling the information and coordination gap in the first phase after major disasters.

GDACS provides real-time access to web-based disaster information systems and related coordination tools. See: http://portal.gdacs.org/about/AboutGDACS/tabid/137/Default.aspx

Google Earth: An advanced two and three-dimensional cartography software program that produces accurate visualization of any point on Earth developed by Keyhole Incorporated in 2001 and acquired by Google in 2005. Offshoot services include Google Maps, Google Ocean, and Google Stars. Operates on 15 variants of Linux along with Apple and Microsoft-based Operating Systems. Latest release was published as version 6.0 November 2010.

Global Position System (GPS): A space satellite−based network developed to provide accurate geospatial reference(s) to fixed and mobile receivers. Designed and initiated by the U.S. Department of Defense in 1973, it has since been made accessible to any compatible device for both consumer and commercial entities. GPS technology is often used in wireless phones to support built-in mapping applications.

Global System Mobile (GSM): Mobile/wireless network Time Division Multiple Access (TDMA) protocol used to communicate between a radio tower and handheld or small form-factor devices for voice and data communication links. Widely used. GSM devices also store subscriber authentication information on a Subscriber Identity Management (SIM) card which can be replaced at anytime with another user's SIM card. Not all devices have this capability to be replaced with another SIM module, i.e.; tablets computers with SIM.

High Speed Packet Service (HSPA)+: Next generation mobile/wireless network protocol used to communicate between a radio tower and handheld or small form-factor devices for voice and data communication links. Widely used. Also known as Evolved High Speed Packet Service (+). It is related to UMTS.

Information and Communications Technology (ICT): The international term for IT (information technology) due to the importance of radio communications in many parts of the world.

Internet Engineering Task Force (IETF): A volunteer group of expert engineers and managers who collaborate to share ideas, innovation, research, standards, and protocols funded and managed by the International Telecommunications Union (ITU).

International Telecommunications Union (ITU): The telecommunications standards organization under the guidance and management as an organization funded by the United Nations.

iPad: Apple Computer tablet computer.

iPhone: Apple Computer mobile phone.

International Society for Photogrammetry and Remote Sensing: Founded in 1910 by Professor Dolezal, it is the oldest recognized remote sensing organization. It developed standards for cartography and information sciences including mapping standards and field survey design.

Java (script): A computer programming language released by Sun Microsystems in 1995.

JSON/GeoJSON: A JavaScript - based programming language developed by Douglas Crockford in 2001. JSON is an acronym for Java Script Object Notation.

Ka: Abbreviation for K “above”; a microwave frequency used to transmit voice and data between a ground station and an orbiting satellite above the Earth operating in the 26.5 to 40 gigahertz frequency range.

Ku: Abbreviation for frequency "under" the K band. Used for stationary fixed satellite systems used in broadcast or ground based tracking systems. Band operates in the 12 to 18 gigahertz frequency range.

Kb: Abbreviation for Kilobits; A kilobit is 1000 bits (decimal), 1024 bits (binary). 1 kilobit = 10^3bits = 1000 bits

Kizuna: A Japan Aerospace Exploration Agency (JAXA) funded, low-Earth orbit satellite capable of transmitting voice and data between different regions of Asia at very high speed data rates and capacity. It is optimized to support disaster relief operations.

Keyhole Markup Language (KML): A JavaScript-based programming language used to place metadata onto the Google Earth or Google Map application.

KMZ: Keyhole Markup Zipped. A set of KML files compressed into a single file. See KML.

Local Area Network (LAN): A network architecture that connects a group of computers to be accessed through a network switch and/or router, enabling the sending and receiving of shared information. LAN connectivity between users is distance-limited by the technology that was in use when the term was coined. In general terms, this limitation still exists today and is considered to be a location within 500 feet of the network switch or router. LANs can be divided into segments and interconnected by daisy chaining network components that effectively extends reach through the use of fiber or wireless point-to-point technology.

Linux: A computer operating system designed by Linus Torvalds in 1991 that can run on most computers in production since 1990. It became famous in part because it is freely available under a General Public License.

Light Radio: A next generation mobile wireless telecommunications technology developed by Alcatel – Lucent in 2010. Research and development has been largely completed with field trials beginning in the fall of 2011 through 2012.

Long Term Evolution (LTE): A mobile/wireless next generation network protocol used to communicate between a radio tower and handheld or small form factor devices, for voice and data communication links. Forecasted to be in service in some parts of the world in 2011. LTE is closely aligned to CDMA based platforms but has also been confused with next generation GSM technology.

Mbps: Megabits per second. One Megabit is 1000 kilobits (10^6 - one million bits). See Kb / Kilobits.

Metadata: One (of many) definitions is information that describes or creates a profile of data, or "data about data." Satellite imagery consists of the actual image and special metadata that describes or specifies how the imagery can be used on a map. This example would include a metadata layer consisting of geographic coordinates known as the Coordinate Reference System (CRS) including latitude and longitude plus other important information, such as resolution, and matched to a geographic standard such as World Geodetic System 84. Other forms of metadata are Twitter posts or Short Message Service messages that include definable information that can be placed on a map.

Megahertz: A Hertz is defined as a cycle per second. One Megahertz translates to a million cycles (10^6) in one second.

Microsoft: One of the first consumer-oriented computer application companies. Founded by Bill Gates and Paul Allen in 1975, Microsoft became a global standard for personal computer operating systems and office applications over the next three decades. Microsoft's first mapping application began in 2005 in both client-based (Streets − 2006) and Internet access- based versions, first as Microsoft Virtual Earth, and now as Bing Maps.

MicroSD: See SD Memory Card.

Miyagi Prefecture: A jurisdiction in the Tohuku region on the island of Honshu, Japan, that was struck by an extremely large earthquake (9.0) and 10-meter high tsunami originating 72 kilometers to the east.

Multi-Media Messaging Service (MMS): A smartphone or network handheld device capable of sending multi-media-based data over a telecommunications wireless network. Example: a user's mobile phone equipped with a

built-in digital camera can store and then forward a picture to another mobile phone device if both are subscribed to an MMS service. The MMS standard, which is also a protocol, can also be used to send a media file to Web-based social media applications including Facebook.

North Atlantic Treaty Organization (NATO): A military alliance, often assigned humanitarian support roles by their respective member governments. Alliance members include: Albania, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Turkey, the United Kingdom, and the United States.

NetHope: A consortium of 33 of the largest non-government organizations founded in 2001, specializing in humanitarian assistance response. It is headquartered in McLean, Virginia, with a focus on Information Technology challenges.

Naval Research Laboratory (NRL): The research and development group of the United States Navy's Office of Naval Research.

National Oceanic and Atmospheric Administration (NOAA): An agency of the U.S. Government with mandates including weather analysis, meteorological satellite operations, monitoring ocean conditions, environmental analysis of oceanic and atmospheric conditions, and scientific research.

Open Geospatial Consortium (OGC): An international industry consortium of 439 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards.

OpenStreetMap (OSM): A creative commons, or general public licensed mapping application hosted by three computer centers; University Central London (U.K.) VR Center, Imperial College (London, U.K.) and Bytemark Hosting (U.K.). OSM is an open-source mapping service which is published much in the same way Wikipedia is, through volunteers around the world. See http://www.openstreetmap.org

P−3 Orion: Lockheed Martin four-engine turboprop aircraft in use by military organizations worldwide. Used extensively as an aerial imagery platform. The NP-3D is a specialized research version operated by the Naval Research Laboratory.

Playbook: A Research In Motion (RIM) tablet computer.

Quality of Service (QoS): An Internet Protocol process in which an Internet packet can be prioritized based on a header label identifying it as to its type of media (text, video, voice), which is then managed by network devices as the packets transverse connected computers locally or globally across short or long distances. QoS is often used to manage different priority levels of Internet Protocol (or IP) traffic going over the network.

Request For Comment (RFC): A memorandum published by the Internet Engineering Task Force (IETF), which describes and illustrates standards and protocols for use with Internet connected services and systems.

RQ−4 Geobar Hawk: A military unmanned surveillance aircraft designed and built by Northrop Grumman. The prototype was built in 2001 and continues in production today. Powered by a single Rolls Royce Turbine engine, the aircraft has a range exceeding 24,000 kilometers with an endurance of up to 36 hours and is available in five different versions. Operators include the U.S. military and NASA.

South American Defense Council (SADC): A military alliance created in 2008 as an agency, under the guidance of the Union of South American Nations. Members include Bolivia, Columbia, Ecuador, Peru (Andean

Community of Nations), Argentina, Brazil, Paraguay, and Uruguay (Mercosur), and independent's Chile, Guyana, Suriname, and Venezuela. A similar organization would be the North Atlantic Treaty Organization (NATO). See: http://www.unasurcds.org

Sahana: An open-source disaster management system application used in humanitarian disasters. Originally developed to manage logistics data during the Indian Ocean tsunami that struck Sri Lanka in 2004 by the Sri Lankan government and Swedish International Development Agency it has been used in more than eighteen different disaster events worldwide. The non-profit organization and its Foundation (established 2009) continue to expand its capabilities.

Search and Rescue (SAR): A mission of different specialists consisting of a group of volunteers or professional experts in the field of emergency rescue of people during a disaster on land or sea.

Security Digital (SD) Memory Card: A form factor and technical standard for non-volatile memory cards used in smartphones, computers, cameras, and video equipment developed by the SD Card Association.

Shortcodes: A specialized set of three, four, five, or six digits used to send or broadcast a text message to a destination. The destination is normally not another mobile phone but a network-connected computer server and associated database. HA/DR shortcodes are used to send emergency messages or other forms of data for publication on a map, or entry into a database for analysis such as medical research.

Short Message Service (SMS): A text messaging application between wireless mobile phones. SMS messages reference the user's mobile telephone number as its identifier.

Type of Service (TOS): The ability of an application or service to embed a classification or label of Internet Protocol−based network traffic to help determine its bandwidth priority requirements. The standard offers the ability to label the sending and receiving of Internet packets with low delay, high throughput, and high reliability by the use of embedded header tags within the IP (Internet Protocol) header which is read by a network's routers and switches to determine control, priority, and (up to) five different queue (classification) levels. Internet traffic TOS has not been widely adopted by independent internet service providers or telecommunications carriers. TOS will be replaced by Differentiated Services Code Point (DSCP) as IPV6 (Internet Protocol Version 6) replaces IPV4 (Internet Protocol Version 4.)

Twitter: Internet-accessible social media posting service developed by Jack Dorsey, Noah Glass, Evan Williams, and Biz Stone in 2006. Users post "Tweets," which are then broadcasted to a user's subscriber list that can be published in private or public formats. Those that are set to public are searchable by Internet Search engines such as Google, Bing, and Yahoo!. User's posts can also be streamed or linked to non-Twitter based applications such as Facebook or a map program such as Ushahidi.

Unmanned Aerial Vehicle (UAV). Common term for remotely piloted or autonomous, aerial vehicles and their support/control system.

United Nations Office for the Coordination of Humanitarian Affairs (UN−OCHA): Formed in 1991 with U.N. General Assembly resolution 46/182 to improve on the response to disaster relief challenges the United Nations had organized under the Department of Humanitarian Affairs in 1972.

United States Agency for International Development (USAID): A department of the U.S. State Department responsible for administering U.S. policy for funding international aid. Established in 1961 by President John F Kennedy, its mandate was approved by Congress under the Foreign Assistance Act (1961). USAID's mandate is

managed by the Secretary of State, National Security Council as well as the President's guidance surrounding economic, development and humanitarian assistance around the world in support of the foreign policy goals of the United States.

Ushahidi: A non-profit company developed in Nairobi, Kenya, created in 2008 by Erik Hersman, Ory Okolloh, Juliana Rotich, and David Kobia. Initiated on the idea of political activism tracking needs in their native country, they developed Web-based interactive mapping technology and ways to place metadata (news articles, citizen journalism) on digital cartography maps. The software is widely used for disaster information management and publication.

United States Geological Survey (USGS): A U.S. Government agency responsible for the study of four disciplines (biology, geography, geology and hydrology) and the study of landscapes. Established in 1879 as a department of the Federal Government with oversight by the Department of the Interior, it is a critical agency tracking earthquakes and other geological disasters such as volcanic eruptions and earthquakes. The USGS publishes notifications via email, really simple syndication (RSS), and KML formats.

United States Northern Command (USNORTHCOM): A U.S. military joint operations command. Established in 2002, USNORTHCOM is responsible for U.S. military services required for the continental United States, Canada, Mexico, and portions of the Caribbean including the Bahamas, Puerto Rico, and U.S. Virgin Islands and is headquartered in Colorado Springs, Colorado. In addition to its responsibilities for national defense and security, USNORTHCOM is the U.S. military joint forces coordination center when directed by the Secretary of Defense or the President to support Humanitarian and Civil agencies in need of a crisis or natural disaster. All U.S. joint operations commands have similar policies and mission.

United States Southern Command (USSOUTHCOM): A U.S. military joint operations command. Established in 1963, responsible for U.S. military services required covering 32 countries in Latin America, the Caribbean Sea, and parts of the Atlantic Ocean. Its headquarters is located in Miami, Florida. USSOUTHCOM is one of 9 Unified Commands. See http://uscode.house.gov/download/pls/10C6.txt

Universal Mobile Telecommunications System (UMTS): A mobile/wireless network protocol used to communicate between a radio tower and handheld or small form-factor devices for voice and data communication links. UMTS is a close relative of CDMA technology.

Wide Code Division Multiple Access (W−CDMA): A next generation mobile/wireless network protocol used to communicate between a radio tower and handheld or small form-factor devices for voice and data communication links.

Wi-Fi: Abbreviation for Wireless Fidelity. A LAN wireless technology used to connect a central point to wireless devices such as laptops, handheld personal devices, and other equipment using a wireless standards ratified by the Institute of Electrical and Electronics Engineers (IEEE) in 1997, also known as 802.11. Next generation Wi-Fi speeds have been added to the standard using a letter attached to the 802.11 abbreviation including *A*, ***B,*** *G* and ***N.*** See http://www.wi-fi.org/ for technical specifications.

WiMax: Worldwide Interoperability for Microwave Access (802.16). A microwave high speed radio technology designed for point to multi-point or point to point radio's using spectrum between 2 and 66 GHz. The original specification was 10 to 66 GHz. It is primarily used for backhaul between mobile wireless carrier radio towers. Bandwidth speeds have increased with radios capable of transmitting up to 400 Mbps. See http://www.wimaxforum.org/

World Geodetic System (WGS): The accepted standard used in digital cartography. The standard evolved through scientific research in Europe and North America and has been updated numerous times since it was used for surveying in World War II.

WGS84: A geodetic datum standard to create reference points used to define the shape and size of the earth.

> *The WGS84 datum surface is an oblate spheroid (ellipsoid) with major (transverse) radius a = 6,378,137 m at the equator and flattening f = 1/298.257223563.[6] The polar semi-minor (conjugate) radius b then equals a times (1 - f), or 6,356,752.3142 m.*
>
> *Presently WGS84 uses the 1996 Earth Gravitational Model (EGM96) geoid, revised in 2004. This geoid defines the nominal sea level surface by means of a spherical harmonics series of degree 360 (which provides about 100 km horizontal resolution).The deviations of the EGM96 geoid from the WGS84 reference ellipsoid range from about -105 m to about +85 m EGM96 differs from the original WGS84 geoid, referred to as EGM84.*
>
> Source: http://en.wikipedia.org/wiki/World_Geodetic_System

X24: Exercise 24: A joint military and civilian exercise series simulating disaster scenarios in different parts of the world and coordinated through San Diego State University.

Extensible Markup Language (XML): A document (text-based) interface standard used by programmers to exchange, transfer, or subscribe information from one source format to another. API developers often rely upon a data file's ability to be subscribed or exchanged from its source point using XML to retrieve it and then create a program to manipulate the data into a new published format. It is also used to push data (and/or metadata) to a destination when the originating source application is not the same as the destinations.

YouTube: A video-based, multi-media social media Web portal created by Steve Chen, Chad Hurley, and Jawed Karim in 2005. The company was acquired by Google in 2006. YouTube video files are often used as a source of information that is then placed on digital maps.